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See Advertisement page 60, April 3. 2402

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ROYAL CORPS OF NAVAL CONSTRUCTORS.

A Competitive Examination for one or more posts as PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the Royal Naval College, Greenwich, in June next.

The Regulations and full particulars of the salary, prospects of promotion, etc., may be obtained from the Secretary (C.E.), Admiralty, S.W.1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience, not later than 23rd April.

Preference will be given to ex-service men.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE.

In conjunction with the above examination, there will be a Qualifying Examination for the admission of Private Students of Naval Architecture to the Royal Naval College, Greenwich. Applications for the Regulations, etc., should be made as in the case of the examinations for the post of Probationary Assistant Constructors (see above).

Private Students are at present required to pay a fee of £30 a session whilst at the College, but this fee will probably be increased in the near future. H 726

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TENDERS.

HEATING.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive

Tenders before Eleven a.m., on Tuesday, 28th April, 1925, for the INSTALLATION of ACCELERATED LOW PRESSURE HOT WATER HEATING, at Aytoun Street Employment Exchange, Manchester.

Drawings, Specification, a copy of the Conditions and Form of Contract, Bills of Quantities, Form for Tender, etc., may be obtained from the Contracts Branch, H.M. Office of Works, King Charles Street, London, S.W.1, on payment of One Guinea. (Cheques payable to The Commissioners of H.M. Works, etc.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. H 710

METROPOLITAN ASYLUMS BOARD.

TO LAUNDRY ENGINEERS.

The Board invite

Tenders for the Revision of

LAUNDRY ENGINEERING ARRANGEMENTS at the South Western Fever Hospital, Landor Road, Stockwell, S.W.9, in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawings, and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after THIS a.m., on Wednesday, 8th April, 1925, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m., on Monday, 27th April, 1925.

(By Order) G. A. POWELL,
Clerk to the Board. H 720

CONDENSING PLANT AND MOTORS FOR SALE.

Sealed Tenders will be received by the DIRECTOR OF ARMY CONTRACTS up to Eleven o'clock a.m., on the 29th April, 1925, for the following:—

TWO SETS SURFACE CONDENSING PLANT, complete with Edwards Patent Enclosed 3-cylinder Air Pump and external Condensate Pump.

TWO ELECTRIC MOTORS, each 11 HP. shunt wound 170 r.p.m., 500 volts, D.C.

TWO DRUM TYPE STARTERS for above motors.

The plant, etc., is at the Royal Arsenal, Woolwich.

Forms of Tender may be obtained on application to the DIRECTOR OF ARMY CONTRACTS (D.C. Sales), Caxton House, West Tothill Street, S.W.1. H 677

METROPOLITAN ASYLUMS BOARD.

TO ELECTRICAL ENGINEERS.

The Board invite

Tenders for the Installation

of ELECTRIC LIGHTING, NEW MAIN SWITCHBOARD, and ELECTRIC POWER CABLES, etc., at the Grove Park Institution, Lee, S.E.12, in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Bills of Quantities, Drawings and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Thursday, 9th April, 1925, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m., on Monday, 27th April, 1925.

G. A. POWELL, H 719
Clerk to the Board.

WEST WHARF, CARNWATH ROAD, FULHAM, S.W.6.

DRY DOCKING, etc., OF PONTOON AND DREDGING WORK.

The METROPOLITAN ASYLUMS BOARD invite

Tenders for the following

WORKS:—

(I) Drydocking, Repairing and Painting Floating Pontoon and Repairing Dolphins and Supporting of Pier Brow; and

(II) Dredging Works in the vicinity of the Pontoon.

Specification, Conditions of Contract and Form of Tender for each work may be obtained at the Office of the Board, Victoria Embankment, London, E.C.4. Intending Contractors should state, when applying for Tender Forms, which work it is proposed to Tender for.

Tenders for each work, addressed as noted on the Forms of Tender, must be delivered at the Office of the Board not later than Ten a.m., on Wednesday, 22nd April, 1925.

G. A. POWELL,
Clerk to the Board. H 733

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:—

92 tons STEEL RAILS (B.S., F.B. 60 lbs.).

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked, "Tender for Steel Rails," must be left with the undersigned not later than Twelve Noon, on Friday, the 24th April, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for each copy of the Specification.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, of 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
2nd April, 1925. H 701

URBAN DISTRICT COUNCIL OF GOOLE.

The Goole Urban District Council invite

Tenders for Supplying, Erecting and SETTING TO WORK a STEAM PUMPING PLANT, at their new Waterworks Borehole, at Pollington Pumping Station, near Snaith.

The Plant will consist of a Borehole Pump capable of lifting 56,000 gallons of water per hour from a depth of 200 feet below ground level, and a Force Pump for delivering the same quantity of water to Goole against a total head of 320 feet, two Boilers, an Economiser, an Overhead Traveller, an Electric Lighting Set, and all necessary auxiliary gear.

A preliminary Plan of the suggested lay-out with copies of the Conditions of Contract and Specification, can be obtained on payment of a deposit of £5 (which will be returned on receipt of a *bona fide* Tender) at the Offices of the Council, Stanhope Street, Goole, or at the Offices of the Consulting Engineer, Mr. H. J. SILCOCK, M.Inst.C.E., 25, Victoria Street, Westminster, and 10, Park Row, Leeds.

Sealed Tenders, endorsed "PUMPING ENGINES," must be addressed to the Chairman of the Gas & Water Committee, and be delivered at the Council Offices, Goole, not later than the 13th May, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

J. W. PULLON,
Clerk to the Council.

Council Offices, Goole.
26th March, 1925. H 649

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

Tenders for:—

LOCOMOTIVE TANK ENGINES.

Tenders due on the 5th May, 1925.
Tender Forms obtainable from above. H 725

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Grinding Machine Demonstrator.

—WANTED, DEMONSTRATOR SALESMAN, thoroughly conversant with modern cylindrical grinding machines, external and internal, to assist large sales force in selling in Great Britain two very well-known makes of these machines.—Address, with full particulars, age, education, training and experience, H 716, Offices of ENGINEERING.

MANCHESTER CORPORATION WATERWORKS.

HAWESWATER SCHEME.

The Waterworks Committee require the

Services of Several Civil

ENGINEERING ASSISTANTS (Three grades). Application forms, which can be obtained from the SECRETARY, Waterworks Offices, Town Hall, Manchester, must be delivered not later than the first post on the 27th April, 1925. H 706

Blue Printing.—Man to Take

Charge of Manufacturing Engineers' Blue Print Room and Drawing Files. Must have knowledge of Rotary Blue Printing Machines and modern Photostatic and Reproduction processes, together with experience of routine filing and card indexing.—Address, stating age, experience, and salary required, H 631, Offices of ENGINEERING.

Wanted, Marine Engineer

with Board of Trade Certificate for motor engines, or equivalent endorsement, for service in motor vessel, Red Sea Trade. First-class certificate preferred.—Write, stating full particulars, experience, age and salary required, to THE HALAL SHIPPING CO., LTD., 3-5, Tooley Street, London, S.E.1. H 712

Nigeria.—Junior Engineer

for Cold Storage and Ice Making Plants; experience with Ammonia Compression Plant, Gas Engines and Producers and Electric Motors is essential. Full particulars of experience and age.—BOX G 57, LEE & NIGHTINGALE, Advt. Offices, Liverpool. H 704

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MUNICIPALITY OF GEORGE TOWN, PENANG, STRAITS SETTLEMENTS.

ASSISTANT ENGINEER.

The Municipal Commissioners of George Town, Penang, require an

Assistant Engineer, age 25 to

32, preferably unmarried, on a three years' agreement with possible extension. Applicants must have had a good technical education and a regular training as pupil and assistant in a Municipal or County Engineer's Office, with experience in Municipal and general engineering work, including Roads, Buildings, Bridges, Sewerage and Conservancy details, and the control of workmen. Preference will be given to candidates who have a knowledge of the design of Sewage Works and who have passed the Testamur Examination of the Institute of Municipal and County Engineers.

Salary, $5400 for the first year, rising if the officer remains in the service by biennial increments of $300 a year to a maximum of $9000 per annum, paid monthly in dollars, the currency of the Colony, the value of the dollar being 2s. 4d. sterling. The pay of the appointment at this rate for the first year would be £630. An allowance for the maintenance of a motor car when on duty will be granted. Free passage will be provided, with half-pay during the voyage out. The selected candidate must pass an approved medical examination.

Applications, stating whether married or single, age, birthplace, and giving details of education, training and experience generally, with particular reference to the items mentioned above, and copies (only) of testimonials, to be lodged with Messrs. PRICE & WILLIAMS, M.M.Inst.C.E., 180, Hope Street, Glasgow, agents for the Commissioners (who will give further particulars if requested), not later than Tuesday, 21st April, 1925. H 722

Engineer (Outside Structural

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thorough knowledge Sugar Machinery, REQUIRED, Glasgow; able prepare schemes, costs and plant lay-out, state full particulars, age, previous experience.—Address, H 637, Offices of ENGINEERING.

Draughtsman, with all-round

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Wanted, Mechanical

DRAUGHTSMAN, by West of England firm of Engineers, with experience in automatic and semi-automatic machinery. State age, experience and salary required.—Address, H 734, Offices of ENGINEERING.

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QUIRED for City office of Mechanical and Colonial Engineers, must have had shop and foundry experience.—Address, giving particulars, age and salary required, H 717, Offices of ENGINEERING.

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Required Immediately, Three

ENGINEERING DRAUGHTSMEN with thorough knowledge of and experience in the design of heating and ventilating installations, domestic hot water apparatus, and preferably, also vacuum cleaning plant.

Candidates must have served in H.M. Forces during the War,

Applications, in writing, to W.Y., c/o CHARLES BARKER & SONS, LTD., 31, Budge Row, E.C.4, not later than 18th April, with not more than three copies of recent testimonials and full particulars of qualifications, practical experience, war service, age, and salary required. H 711

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STUDIES OF ATOMIC NUCLEI.

ON Friday, March 27, a lecture on the above subject was delivered at the Royal Institution by Sir Ernest Rutherford, F.R.S.

In opening his discourse, Sir Ernest said that it was his intention to give an account of two lines of work pursued during the past 12 months at the Cavendish Laboratory. The investigations in question were concerned with the nature of the forces around the nucleus, and with the structure of this nucleus. Both researches were based on the study of the effects produced by very swift α particles shot through matter. We knew that the atom was very small. Two hundred million of them arranged in line would make up about 1 in. Each atom consisted of a positively charged nucleus surrounded at a great distance by electrons, which provided sufficient negative

Fig. 1.

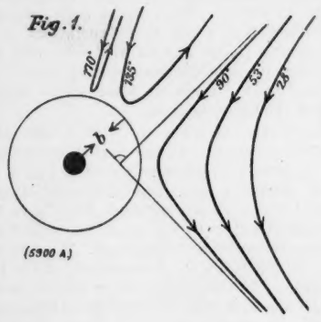
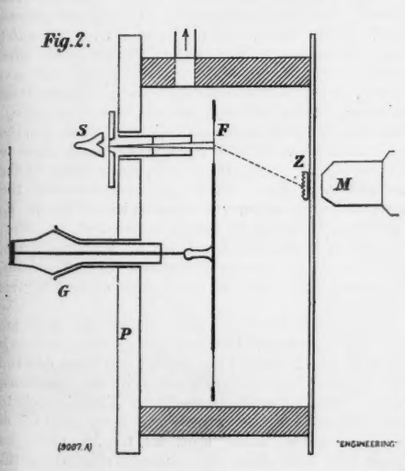


Fig. 2.



charges to render the atom neutral. In the case of gold there was a balance of 79 positive charges on the nucleus, and this also was number of the external electrons. These electrons were probably in motion. If an atom were magnified many thousand times it might be represented in size by a tennis ball, in which case the nearest of the surrounding electrons would be situated on the confines of that lecture hall, and the outermost would be a few kilometers distant.

The space between the nucleus and the innermost of the surrounding electrons had a radius of the order of 10^{-11} cm. This was the region which they had been studying at Cambridge, by probing it with α particles ejected at a speed of some 10,000 miles per second from some radio-active body. So swift were these particles that they ploughed completely through the atoms encountered in their path. As the result of these collisions a certain scattering of the α particles was produced. If a narrow beam of them were shot through a vacuum they would produce a sharply defined phosphorescent spot on a zinc-sulphide screen interposed in the path of the rays. If, however, air were introduced into the vacuum tube the spot became hazy, as the result of a special kind of collision with the atoms encountered by the rays. The nucleus of an atom and an α particle were both positively charged, and repelled each other. The higher the speed of the α particle the closer could it get to the nucleus, and inversely the larger the charge on this nucleus the greater would be the distance of closest approach. Hence when α rays were shot through the lighter elements they got closer to the nucleus than they could do in the case of the heavier elements. The scattering of the particles was not, it would be seen, due to an actual collision between the particle and a nucleus, but to the repulsive forces between the positive charges concerned. These forces were extremely large. Assuming that they followed the inverse square law, it could be shown that the path of the particle in the neighbourhood of the nucleus was a hyperbola, as indicated in Fig. 1. In some of the cases there represented the collision was nearly a head-on one, whilst in others

Fig. 3.

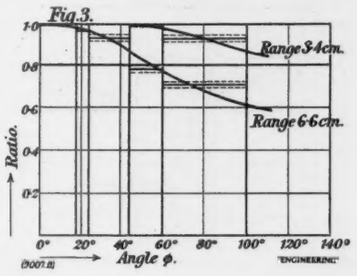
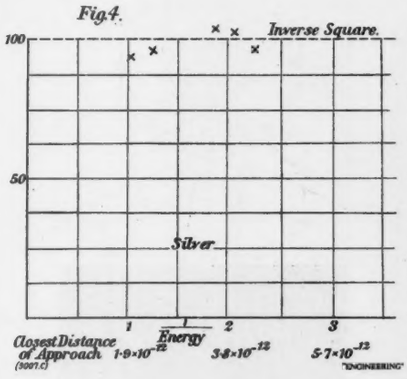


Fig. 4.



the angle between the asymptotes might be 130 deg., 90 deg., down to 28 deg. It would be obvious that to get the closest possible approach to the nucleus we must use the swiftest particles, and must arrange matters so that the particle was scattered nearly backwards. By a study of the numbers turned through different angles of reflection, the law of force ruling in the neighbourhood of the nucleus could be deduced.

The views now held in this regard originated in the experiments made at Manchester by Marsden and Geiger, who worked with α particles travelling at different speeds. It could be shown mathematically that if the forces concerned were electric and obeyed the inverse square law, the proportion of particles deflected through a stated angle would vary inversely as the square of the kinetic energy of the particle, or as the inverse fourth power of its velocity; whilst, if ϕ denoted the angle through which the particles were deflected, the number deflected through this angle would be proportional to $\frac{1}{\sin \phi/2}$.

In the experiments of Marsden and Geiger, both rules were found to hold good, but the α particles used were not of the swiftest type, the range in air being only about 4 cm. It had thus been necessary to repeat their work, using the swiftest α particles and with the greatest possible accuracy, if we were to get some light on the nature of the forces in the immediate neighbourhood of the nucleus. Unless we were able to measure these forces we could not really know anything of the nature of the nucleus.

Eight years ago it was already evident that the law of the inverse square must break down in certain conditions. If we fired α particles through hydrogen the nucleus of the latter were in certain cases sent off with a very great velocity. The α particles get very close indeed to the nucleus of the hydrogen atom, and in 1919 it was definitely proved that in such collisions the inverse square law broke down completely.

In other experiments the α particles were shot through thin foil. A certain number of them came away in the backwards direction, but the proportion thus deflected was very small indeed, amounting to not more than one in 100 million. An arrangement used for making observations of this kind was represented diagrammatically in Fig. 2, where the radio-active material was indicated at S, the metallic film was situated at F, and the particles which came through this were observed under a microscope at the zinc sulphide screen, Z. This method of counting by direct observation was adopted because there were great difficulties in this kind of experiment in making the count by electrical means. The source of the α rays used was a thin walled glass tube containing radon, a device which had been in use for the past 20 years but had that week been announced as a new discovery by the daily Press. Each α particle as it struck the screen produced a scintillation. The number observed in a stated time was not uniform, being governed by the laws of chance. At small and moderate angles of deflection the number was far too great to be counted by the eye. The speaker had accordingly interposed in the path of the rays a rapidly revolving disc having a slit in it occupying $\frac{1}{1000}$ of the total area. To reach the screen the rays had to pass through this slit and the number was thus reduced in the ratio stated. This enabled counts to be made equivalent to 60,000 impacts per minute.

At large angles of deflection, such as 130 deg. to 140 deg., the particles could, however, be counted directly, and such particles we knew must have gone very close to the nucleus of an atom. In the experiments he had made in conjunction with Mr. Chadwick, the angle at which the counts were made was kept constant and the velocity of the particles varied, by interposing in their path sheets of mica of known thickness. If the inverse square law held, the number reaching the point of observation should vary as the inverse square of the kinetic energy of the particles. If this was not found to be the case it was evident that the law broke down.

The experiments were found to be full of pitfalls, the greatest circumspection being necessary. Indeed, an observer gifted with a little imagination could make more "discoveries" in a week than he could disprove in the following ten years. No single result, taken by itself, was of any value as the number reaching the screen was governed by the laws of chance.

Experiments of a similar kind made by Bieler on the lighter elements indicated that the law, above stated, held for these, until aluminium was reached, when it broke down completely. Bieler compared the numbers coming through different metallic foils with the numbers observed in the case of gold. The ratio of the number deflected at different angles should be constant if the inverse square law held, but when gold was thus compared with aluminium, using rays having a range of 6·6 cm., the ratio was only 60 per cent. of what it should have been if the normal law were obeyed. His results were plotted in Fig. 3. Bieler had attributed his results to the existence of an attractive force varying as the inverse third power of the distance, which became sensible at small distances from the nucleus, and he was able thus to give an approximate account of his experiments.

Taking as 100 the proportion of particles which should be deflected if the inverse square law held, the agreement in the case of silver was very good (see Fig. 4) showing that the law held up to a distance of 2×10^{-12} cm. from the centre of the nucleus, which was as close as the α particles could get. The inverse

square law also held for gold, in which case the α particles got to within 3×10^{-12} cm. of the centre. They next tried uranium, and to their surprise and, he might almost say, horror, the results agreed with those established for gold. On the other hand, when aluminium was examined they got the curious curve reproduced in Fig. 5. Here it would be seen that, in place of a horizontal line at 100, they got a curve which fell away from this as the energy in the particles increased. The result agreed with those of Bieler so far as the latter had gone, but on using α particles of still greater energy it was found that the curve jumped up again as indicated.

One noteworthy point was that the minimum of the curve corresponded exactly to that range of the α particle at which protons were first shot out of the aluminium nucleus. The region in which the curve rose again was, accordingly, that in which the aluminium atoms were being disintegrated with the liberation of protons, though, of course, these protons were expelled only in the case of exceptionally favourable collisions.

In the case of gold and uranium they had found the inverse square law to hold up to as close to the nucleus as the α particles could penetrate, viz., up to a distance of about 3×10^{-12} cm. from the centre. Now, uranium was radio-active, ejecting α particles with a velocity which would be that attained if the particle started from rest at a distance of 7×10^{-12} cm. from the centre and acquired its velocity solely from the repulsion of the electric field through which it had to pass on its way out. It appeared, therefore, that in this case the inverse square law held when it ought to break down.

This result might be explained if the nucleus consisted of a central or inner nucleus and a system of satellites (each of which might be a doublet), as represented diagrammatically in Fig. 6. If the aluminium nucleus had this structure, then, if the α particle penetrated into the region occupied by the satellites, the force acting on it would be diminished by the whole of the charges carried by the positive satellites shown, and the scattering would therefore be reduced, as was found to be the case experimentally. If, however, still faster particles were used, which were able to penetrate completely through the field occupied by the satellites, the field of force in which the particle then moved would be much the same as outside the band of satellites, and the scattering would increase again and might conceivably reach the normal value. So far they had, however, not found any minimum in the curve for uranium corresponding to that observed with alumunium, but this minimum was being carefully looked for. Another matter being investigated was the atomic number of the element at which this system of satellites first came in.

In another series of experiments, also made at the Cavendish laboratory, Mr. Blackett had photographed by Wilson's method the tracks of α particles through nitrogen and other gases. This was done in the hope of getting a record of collisions in which the nitrogen nucleus was disrupted. Calculation indicated that anything from 100,000 to a million tracks must be photographed in order to attain success, since in only about one collision in 40,000 was there any very close approach of an α particle to an atomic nucleus.

In all, Mr. Blackett had photographed about half-a-million tracks. In each case two photographs were taken simultaneously, the plates being at right angles to each other. By a comparison of the two it was possible to fix with accuracy the actual path in space of every particle which appeared on the plates. The greatest care was, however, necessary, as only perfect photographs could be of use. In all Mr. Blackett secured about 16 photographs showing close collisions between α particles and the nucleus of nitrogen atoms. Of these, eight were found to have obeyed accurately the laws of elastic collision, both momentum and energy being conserved; in eight more the collision had been accompanied by the ejection of a proton from the nitrogen nucleus, one example of which was reproduced in Fig. 7, where the faint track in the backwards direction is that of the proton of which the ionising power is relatively small. In these cases, which represented the disruption of the nitrogen atoms, the laws of elastic collision broke down. Momentum was still, however, conserved, as was proved by the fact that all three tracks lay in the same plane. On the other hand, energy was not conserved. Even in these collisions, however, the track had, it would be seen, only two branches, which seemed to indicate that the α particle was absorbed into the nitrogen nucleus. The latter would thus lose one proton of mass, one which would carry with it one positive charge. It would receive in exchange an α particle with mass four, carrying two positive charges. The atomic weight would therefore become 16 and the atomic number be raised to 8, so apparently the nitrogen atom was converted into one of oxygen, unless, as was possible, an electron had been ejected at the same time as the proton.

Fig. 5.

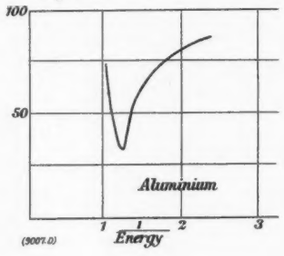
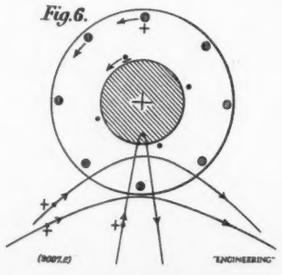


Fig. 6.



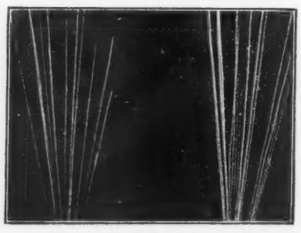


FIG. 7.

As matters stood it would seem as if we had succeeded not merely in disrupting an atom, but in synthesing one; but some 10 years' solid work would probably be necessary to establish really definite conclusions.

DRY DOCK AT CONGELLA, DURBAN.

THE need of enhanced docking facilities has been felt for many years in South Africa, where, apart from the naval graving dock at Simonstown, at which Government requirements naturally take precedence, the only means of docking are provided by a dry dock at Cape Town and a floating dock at Durban. The former has a length of only 529·6 ft. and a depth over sill of 24·6 ft., while the latter has a length of only 475 ft. and a lifting capacity of but 6,500 tons. The Simonstown naval dock has a length of 756·4 ft. and depth on sill of 36·5 ft. so that this dock, which may at any time be unavailable for mercantile vessels, is the only one of a character at all suited to the larger vessels now plying to South African ports.

The idea of providing further facilities has long been mooted in connection with Durban. A dry dock was proposed there in 1888 and the subject was again brought forward in 1897. The matter, however, got no further. The present floating dock was procured in replacement of one supplied earlier, but lost at sea. In 1911 the question of additional docking arrangements again came prominently forward and the form these should take was the subject of careful consideration by the South Africa Railways and Harbour Administration. In the end the idea of another floating dock gave way to the decision to build a dry dock, with the result that the largest graving dock in the southern hemisphere has recently been brought to completion at Congella, in Durban Harbour. This dock is intended to cope with the requirements for many years ahead. It has been planned on the scale of those recently constructed at St. Johns, New Brunswick, and Esquimalt, British Columbia, and under construction at the King George's Dock at Calcutta. Though not quite so wide as the two first, it is wider than the latter. It is of equal length (1,150 ft.) to the first, and in an emergency its length can be extended by an additional 40 ft., when its total would equal the length of the Calcutta dock.

Through the courtesy of the South African authorities we are able to give particulars of the new dock, the site of which is indicated in Fig. 1, while various drawings and reproductions of photographs of the work are shown in Figs. 2 to 35 on pages 439 to 442, page 452, and Plate XXIX which accompanies our issue of this week. The site will be seen to be placed on the western side of the bay of Port Natal. The ordinary shore line is shown in Fig. 1, while a dotted line indicates the alignment to which quays will ultimately be built, the area behind this being reclaimed. The original ground level at the site was only 5 ft. above low water and 1 foot below high water. Three other sites were considered, but the one at Congella was preferred, owing to the excellent natural foundation afforded, which allowed an avoidance of piling, economy in connection with cofferdam work, and the utilisation of spoil from reclamation work close to the dock, &c. The site is also quite close to the railway main line. From its commencement the work has been under the supervision of Mr. W. R. Crabtree, M.Inst.C.E., acting as resident engineer. Mr. H. G. Humby, M.Inst.C.E., 13, Victoria Street, S.W., acted as consulting engineer for the caissons, pumping plant and all work carried out in this country.

A longitudinal section and plan of the dock are given in Figs. 3 and 4 on page 439; a cross-section is given in Fig. 2, while Figs. 5 and 6, on pages 440 and 441, are two views recently taken of the completed work. The illustrations on Plate XXIX relate to the sliding caissons, which are used instead of swinging gates, while Figs. 32 to 35, given on page 452, also show the caissons erected in the dock, and the outer one floated into position outside the entrance. Further sections of the work will be illustrated in a subsequent issue.

As already stated, the usable length of the dock is 1,150 ft. The width at the entrance is 110 ft. The width at floor level is similar, but at coping level for the body of the dock chamber the width is 138 ft. 6 in. The depth at high-water spring tides, on the sill is 41 ft., and at L.W.S.T. 35 ft., spring tides having a rise of 6 ft. The coping level is 12 ft. above L.W.S.T. The floor at the outer end is 40 ft. below L.W.S.T., and has a rise of 1 in 660 towards the head. The chamber is divided into two lengths of 660 ft. and 440 ft. respectively, so that either the whole dock may be used for one large vessel, or two of shorter lengths may be docked simultaneously. The two lengths are separated by an inner sliding caisson, a second (outer) caisson closing the entrance. The caissons are very similar as regards overall dimensions and scantlings, and are interchangeable on their seatings. They are, further, reversible, and, if necessary, can be floated into position against seatings outside their recesses. This allows of an addition to the chamber length in the case of the inner section of 30 ft., and the whole chamber of 40 ft.

The surface level of the rock at the site is indicated in Fig. 3. The side wall foundations were carried

DRY DOCK AT CONGELLA, DURBAN, SOUTH AFRICA.

DRY DOCK AT CONGELLA, DURBAN, SOUTH AFRICA.

Fig. 1.

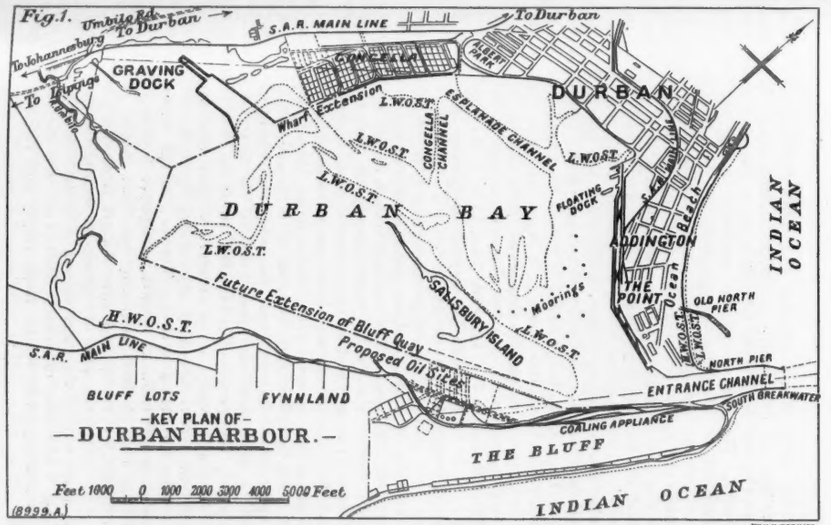


Fig. 2. CROSS SECTION OF DOCK ON A–B LOOKING TOWARDS HEADWALL. SHOWING SECTION OF ARUNDEL CASTLE."

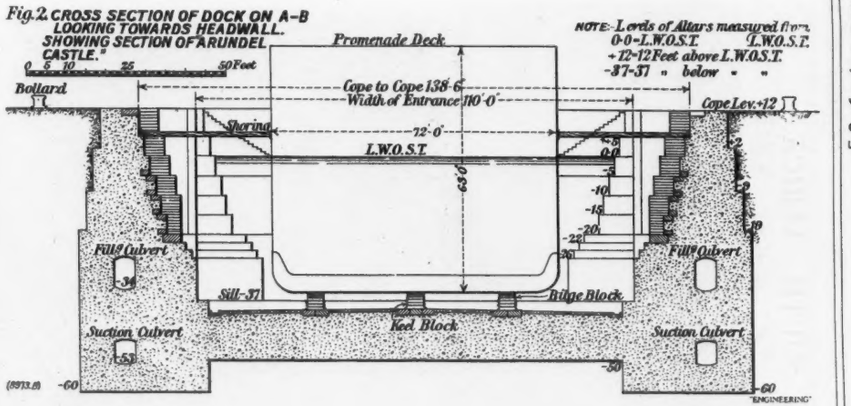


Fig. 3.

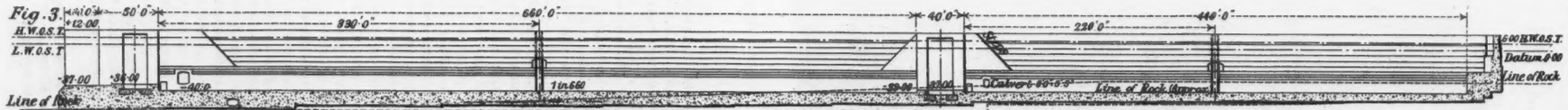
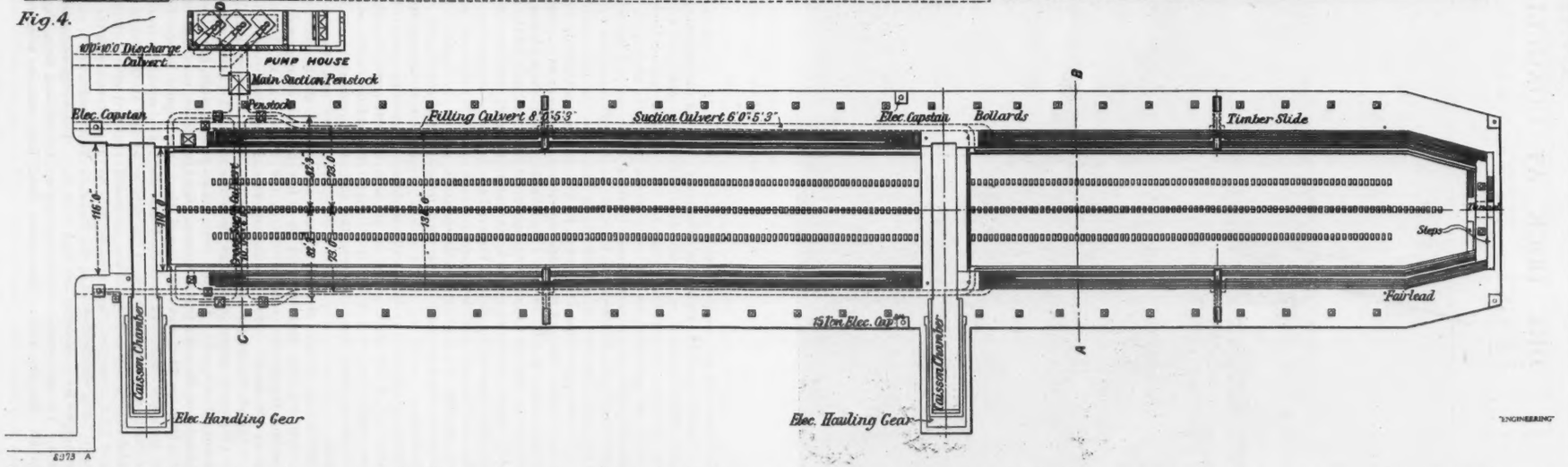


Fig. 4.



down to 65 ft. below datum at the entrance, and 45 ft. at the head of the dock. The walls are of varying thickness, being stepped at the back and finished with a series of altars on the chamber side. At the base they are 27 ft. 9 in. wide for the inner chamber, 29 ft. 6 in. wide for the outer chamber, and 34 ft. wide at the entrance. The thickness in all parts is 9 ft. at coping level. The floor is founded on rock throughout. It is 25 ft. thick at the entrance, but this is reduced at the head end to 6 ft. 6 in. The floor has a slope from centre to sides of 1 in 60. Below the floor is laid a system of 12-in. and 9-in. open-jointed piping, in contact with the rock. This discharges into the leakage pump sump. The concrete for the walls and floor was 7 : 1 mixture, the walls being finished with a 6-in. facing layer of

DRY DOCK AT CONGELLA, DURBAN, SOUTH AFRICA.

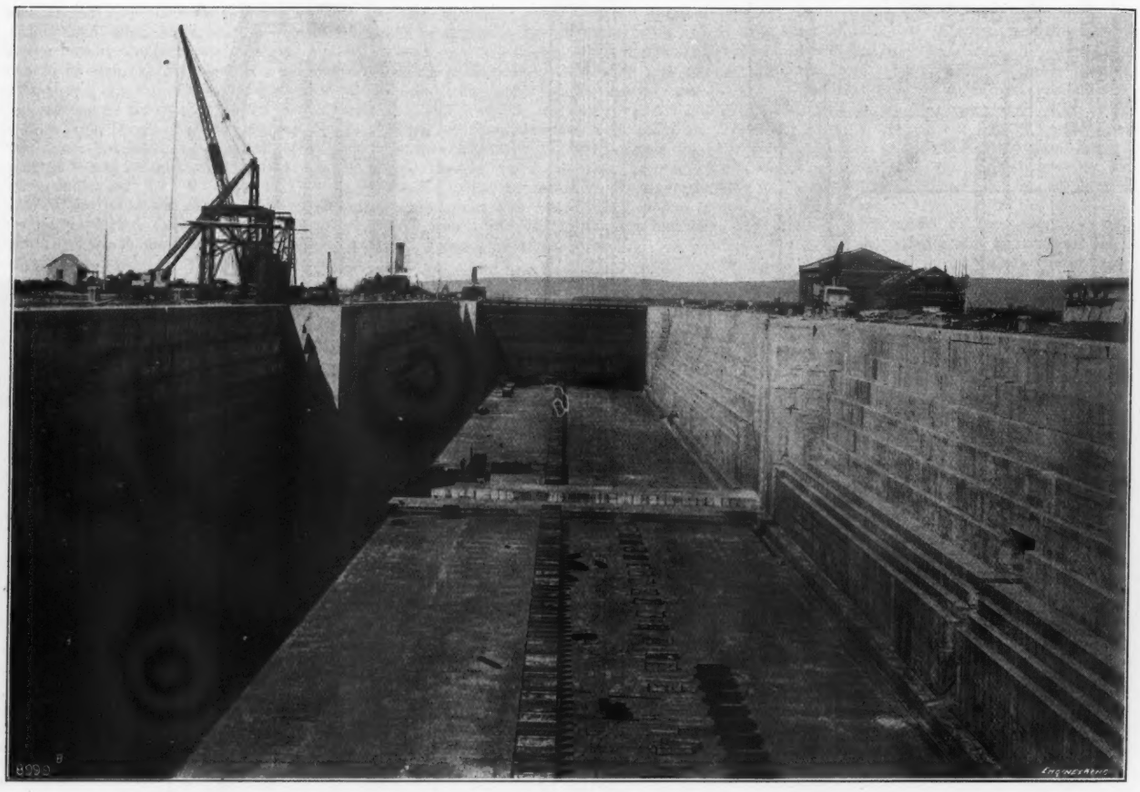


FIG. 5. DOCK CHAMBER, LOOKING TOWARDS ENTRANCE.

3 :: 1. The culverts are all lined with a 12-in. layer of 4 : 1 mixture. The coping and altars are finished with dressed granite, as are also the sills and caisson seatings. In the sides and end wall flights of steps are provided, as well as recessed ladders. Timber slides are also arranged in both inner and outer sections. The keel and bilge blocks are similar in type. They rest on granite laid in the dock floor. The blocks measure 4 ft. by 4 ft. by 5 in., and are spaced, for keel blocks 4 ft. centre to centre, and for the bilge blocks at 8-ft. centres. The blocks have tapered pieces, and are capped with hardwood timber. As regards general equipment, six 15-ton electric capstans supplied by Messrs. Vickers Ltd., are provided on the dock walls for warping vessels in. A large number of mushroom head bollards are also disposed round the dock, 26 ft. back from the coping edges.

The entrance is flanked by two walls at right angles to the axis of the dock. One of these is 200 ft. long while the other is 140 ft. in length. Bollards are placed along these, set near the edge of the coping.

Before passing to details of the caissons and pumping plant we may perhaps refer to a few points regarding the general construction of the main body of the dock. Rock for the concrete work was obtained from quarries opened for the purpose at Clairwood, about five miles from the crushing plant at the site. Granite was drawn from quarries about 50 miles from Durban. Sand was procured from the Bluff and the Umgeni River. The cement used was throughout Pretoria Portland. After the formation of a bund all round the site, to exclude tidal water, open excavation proceeded to a depth of 15 ft. over the whole area, with 1½ to 1 slopes, spoil being dumped outside the embankment to reclaim as far as possible this land to 12 ft. above datum. The next work was the opening up of trenches for the side walls. These were lined by 12 in. by 12 in. timbers, their width being 33 ft. at the bottom and 42 ft. at the top. The rock for the most part was black shale. When this was reached further timbering was unnecessary. The rock was excavated by means of compressed air drills and jackhammers. The water met with was for the most part small, and easily kept in check. After the side walls had been raised above the main excavation, work on the removal of the dumpling was commenced.

In all the work has involved the following quantities, exclusive of the approach basin :—Excavation in earth, 530,000 cub. yards ; in rock, 80,000 cub. yards ; concrete in walls and floor, 228,110 cub. yards ; concrete in culvert linings, 8,130 cub. yards ; granite in coping, risers, altars, sills and quoins, 117,376 cub. yards. The excavated material was used in reclaiming 100 acres of ground.

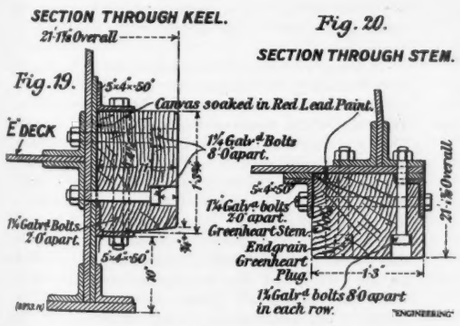
Reverting now to the sliding caissons, these are of rectangular box-shaped construction. They are carried on rollers and are drawn into and out of their recesses by electrically driven cable gear, the motors and winches being arranged in houses placed at the ends of the caisson recesses. The general arrangement is shown in Figs. 7 to 9, Plate XXIX. These and other drawings on this Plate actually relate to the outer caisson. The two differ, however, mainly as regards the upper decking. The outer caisson is furnished with a deck, which, when the caisson is on the seating in the chamber, rises automatically so as to be flush with the coping level. The arrangement provides for heavy vehicular traffic over this caisson from side to side at the entrance. The inner caisson is not provided with a deck of this character, and, when in position across the chamber, can only be used for foot traffic.

The design and scantlings of the outer caisson will be followed from Figs. 10 to 18, on Plate XXIX. Both caissons were made by Sir W. G. Armstrong, Whitworth and Co., Ltd., Shipyard Dept., and temporarily erected in England, being then shipped to Durban and built up on the dock floor where they are shown completed in Fig. 35, page 452. The outer caisson is 46 ft. 9 in. high from the underside of the roller plates running on the rollers on the recess floor, to the top of the sides, this height for the inner caisson being 48 ft. 9 in. The overall length is 116 ft. on the outer face and 112 ft. 6 in. on the inner face. The extreme width over greenheart sealing timbers for the outer caisson is 21 ft. 1½ in., the moulded width being 19 ft. There are five decks. The top or A deck has already been briefly noticed above. It does not form part of the caisson structure proper in the way that the B, C, D and E decks do. These decks will be seen marked in Fig. 10, while Figs. 13 to 15 give half plans of B, D and E. Typical stringers are also shown in Figs. 16 to 18.

The decks are spaced from 13 ft. 6 in. to 14 ft. 6 in. apart, and the stringers about 4 ft. 6 in. or 4 ft. 10 in. apart. The top and bottom decks, B and E, are open and consist merely of horizontal frames stiffened by beams and diagonal bracing. Decks C and D are plated and are watertight. The space between these decks forms three compartments, the centre one, 88 ft. in length, forming an air chamber, and the two end chambers forming scuttling tanks. One of the latter is shown in plan in Fig. 14. The size of the three chambers is stated to be arranged to give together a reserve of buoyancy represented by 6 ft. of freeboard below deck C. The size of the scuttle tanks is sufficient to give a negative buoyancy after the reserve buoyancy has been taken up. With scuttle and water ballast tanks empty, and about 190 tons of ballast on board, the displacement of the inner caisson is about 875 tons, at which the draught is 29 ft. 3 in. For the outer caisson with scuttle tanks empty and 175 tons of solid

DRY DOCK AT CONGELLA, DURBAN, SOUTH AFRICA.

FIG. 6. DOCK CHAMBER, LOOKING TOWARDS HEAD WALL.



ballast on board, the displacement is 935 tons at a draft of 29 ft. 3 in. Top water ballast tanks are only provided in the inner caisson. Three trunks are provided. One in the centre communicates with the air chamber, while the others, placed towards each end, as indicated in Figs. 9 and 14, run down to the bottom deck E.

The main vertical frames, spaced 12 ft. apart and illustrated in Fig. 11, have a width between decks B and C of 2 ft. This increases to 2 ft. 2 in. between C and D and to 2 ft. 4 in. between D and E. The diagonal stiffening consists of channels built up of plate and angles. The intercostals are of angle iron, and are spaced 2 ft. apart.

Deck B, Fig. 13, is divided into 10 panels, by main beams 12 ft. apart; the two end panels are plated, to provide additional stiffness in the neighbourhood of the meeting faces. The main deck beams are 15 in. deep. The side horizontal frames are 4 ft. wide, while the diagonal bracing varies from 6 in. by 3½ in. by 17·9-lb. channel at the two centre bays, to 12-in. by 3½-in. by 32·88-lb. channel, backed by double angles, at the outermost open bays. For the plated end sections 0·38-in. plating is carried on 5-in. by 3½-in. by ⅜-in. beams. Deck C is very similar to deck D, but of lighter scantling. In D, Fig. 14, the main deck beams are 27⅜ in. deep, with three secondary beams 23 in. deep. There is no diagonal bracing under this deck. Deck E, Fig. 15, is partly plated and partly open, there being six open bays in the centre. The main beams of this deck are 20 in. deep. The diagonal bracing consists of channels formed of angles and plates, back to back, giving a web 14 in. by ½ in., the angles being 5 in. by 4 in. by ½ in. For the plated sections 0·64 plate is used. The fixed ballast is arranged on these plated portions of deck E, to which access is given through the two 37-in. by 37-in. trunks from the top of the caisson.

The stringers are illustrated in Figs. 16, 17, and 18. Fig. 17 shows half of the two uppermost stringers (Nos. 1 and 2, Fig. 10) along the inner face. The outer are similar. Fig. 16 is a half-plan of stringers Nos. 3 and 4, while Fig. 18 shows half of the lower stringers Nos. 5 and 6, along the inner face. Again in this case these are similar to those along the outer face. The upper stringers are of 0·38-in. plating and single 3½ in. by 3½ in. by 0·50 in. angle. Their width for the greater part of the run of the sides is 20½ in., increasing at the caisson ends to 30 in. Stringers Nos. 3 and 4 are of 0·50-in. plate, 21½ in. wide, edged with a single angle. These stringers are carried at the same width through the scuttle tanks to the caisson ends. Inside the tanks the stringers are carried round the caisson ends by 0·38-in. plate 30 in. wide, edged with double 4 in. by 4 in. by 0·62 in. angles. Similarly, the watertight bulkhead side of the tanks have stringers 24 in. wide of 0·38-in. plate, with double angles as above. The tanks are also strutted by two 6 in. by 3 in. by 3 in. channels extending between the end stringer and watertight bulkhead stringer. The lower stringers, Nos. 5 and 6, Fig. 18, are also of 0·50-in. plate. These stringers are 28 in. wide for the greater part of the run, with single angles 5 in. by 5 in. by 0·76 in. At the ends they increase to a width of 36 in., as shown.

The roller plates, 12 in. wide by 1·2 in. thick, are carried by longitudinals extending under the sides and supported on the inside by gussets of 0·62-in. plate and angles, from the bottom deck framing. Greenheart timber meeting faces are fitted vertically on the sides at each corner, and along the bottom on each side. The stem timbers are 15 in. by 12 in. thick. They are fixed to the caisson, as shown in Fig. 20. The keel timbers, 15¾ in. by 11 in., are on a level with the bottom deck framing, and are shown in Fig. 19. The sill recess in which the roller path is arranged allows a total of 1 in. freedom of movement. The end seals or stems are fitted opposite the end frames.

The caisson is plated for the three lower strakes with 0·8-in. plate. Then follows one of 0·76-in. plate, above which are three strakes of 0·6-in. plating, followed by the uppermost, which is 0·5 in. in thickness. The plating of the ends is 0·76 in. thick, the lower part, between decks D and E, being cut away, as shown in Fig. 12. The uppermost course of plating on the inner and outer faces extends up above deck B, and is stiffened by 3½-in. by 3½-in. by 0·50-in. angles on the outside.

The fixed ballast placed on Deck E consists of steel punchings set in concrete. The deck is covered with ⅜ in. of asphalte laid on the steelwork. The proportions of the ballast mixture are 1 of Portland cement and 1 of sand, filling the spaces between closely packed punchings, the whole weighing 350 lb. per cubic foot. The surface of the ballast when in place was finished with 1 : 1 cement mortar rendering 1 in. thick.

The A deck, which in the case of the outer caisson rises and falls, but in the inner caisson is fixed, is built up of four 12 in. by 6 in. by 44 lb. girders, with main beams of the same spaced 12 ft. 0 in. apart. The deck planking is carried by 6 in. by 3½ in. by 17·9 lb. channels spaced 18 in. apart. The planking is 3½ in. by 8 in. Dantzig oak spaced ½ in. apart.

The air chamber contains a hand-operated

DRY DOCK AT CONGELLA, DURBAN, SOUTH AFRICA.

Fig. 21.

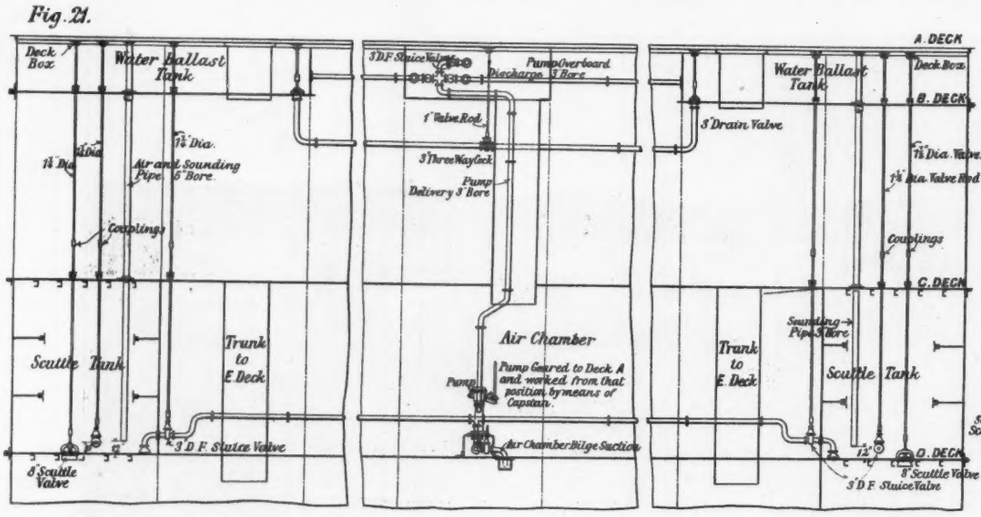


Fig. 23.

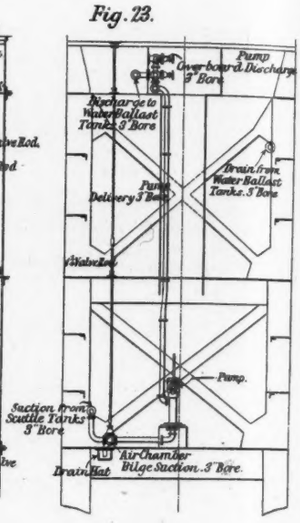

Pump
Overboard Discharge 3" Bore
Discharge to Water Ballast Tanks 3" Bore
Drain from Water Ballast Tanks 3" Bore
Pump Delivery 3" Bore
1" Valve Rod
Pump.
Suction from Scuttle Tanks 3" Bore
Air Chamber Bilge Suction 3" Bore.
Drain Pipe

Fig. 22.

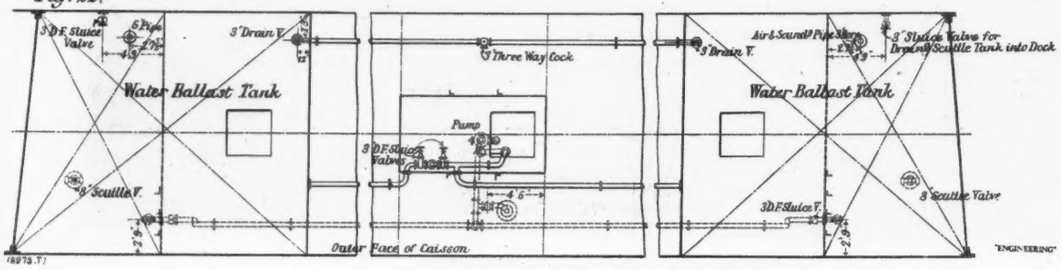


Fig. 24.

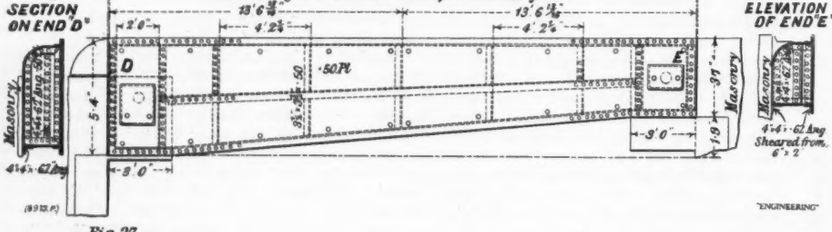


Fig. 25.

Fig. 26.

Fig. 27.

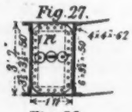


Fig. 28.

Fig. 29.

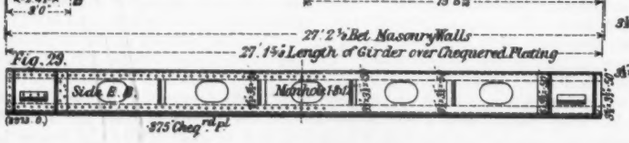


Fig. 30.

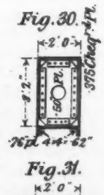


Fig. 31.

Triumph pump, with a cylinder 6 in. in diameter and stroke of 5¾ in., and 3 in. suction. This pump is placed in the centre of the "D" deck and communicates by suction pipes with the two scuttle tanks at the ends, discharging overboard, or can deliver to the top ballast tanks on the inner caisson. The pump also draws from a sump in the air chamber. The scuttle tanks are each fitted with a single 8-in. scuttle valve, communicating with the outside. 3-in. sluice valves are also fitted for draining the tanks when in dry dock. The connections between the top water ballast tanks of the inner caisson are arranged so that water ballast can flow from one end to the other, or one tank can be emptied while the other is kept full. The piping, &c., for the inner caisson is shown in Figs. 21 to 23, above.

The caissons are carried on two rows of rollers, centred 19 ft. 1⅝ in. apart, a distance of 7 ft. 2 in. extending between the centres of the rollers of each row. The rollers are of cast-iron, 18 in. in maximum diameter, the 10-in. rim being finished to a 3-ft. radius. The 6-in. centre hole is bushed with phosphor-bronze, and the rollers work on fixed spindles of steel bar surrounded by a phosphor-bronze sleeve. The spindles have one round and one square end, the latter fitting into a square jaw in the cast-iron carrying brackets. The brackets are fixed to the recess floor.

On being withdrawn from their seatings across the dock chamber, the caissons are hauled into recesses which are covered with troughing filled with concrete. The clear width between walls inside is 27 ft. 6 in. The covering is 1 ft. 11¼ in. deep, the troughing having a depth of 1 ft. 5½ in. The troughing is Dorman Long's section Type E, Max., of a thickness of 1 in. for the top and bottom and 0·636 in. for the sloping sides. At the coping a portable coping girder is provided in each case. That for the outer caisson recess is illustrated in Figs. 24 to 26. It spans the length between the recess walls, the curved side facing outwards and downwards. On the caisson being drawn into the recess the platform, or "A" deck, is forced down by this girder so that it can be drawn under the cover. This will be referred to again later. For the inner caisson a similar girder is provided, but rectangular in cross section. This is shown in Figs. 27 to 31. In both cases these girders are held down by two 1¾-in. bolts at each end let into the masonry, the nuts being accessible in end compartments fitted with coverplates. On the opposite side of the dock girders are also let into the masonry, spanning the shallow recesses into which the caissons are run. In form these girders resemble those on the hauling side, but are of lighter scantlings and are both rectangular in cross-section. They are also made so as to be readily removed in case of need.

(To be continued.)

WIRELESS TRANSMISSION OF PHOTOGRAPHS.—Some interesting exhibits have just been placed in the Western Hall of the Science Museum, Imperial Institute-road, South Kensington, illustrating the process used in the transmission of photographs by wireless. These include a photographic film of the Prince of Wales actually used at the Marconi telegraph office in London for the purpose of transmission, a photograph of the portrait as it was received by wireless in New York, and a copy of one of the American newspapers in which it subsequently appeared.

INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 426.)

Wake Propeller Coefficients.

When the meeting was resumed on the morning of Thursday, the 2nd instant, the chairman, His Grace the Duke of Northumberland, called upon Rear-Admiral D. W. Taylor to read his paper entitled "Wake Propeller Coefficients," which formed the first item on the programme for the day. An abstract of this paper was given on page 429 of our last issue, so that we may at once proceed to deal with the discussion, which was opened by Sir Archibald Denny. Sir Archibald said he had not had time to study the paper closely himself, but had sent a copy to Mr. E. R. Mumford, whose comments he proceeded to read. These were to the effect that, in the absence of complete experimental data, it was useful to be able to evaluate the wake percentage even approximately, but wake was often seriously affected by details of the shaft supports, &c. It must therefore be considered as a modification of the direct fore and aft flow of the water, and was determined experimentally by finding the speed of advance at which the propeller, when separated from the ship model, developed the same thrust for the same revolutions as it did behind the ship model; the difference between these two speeds was the wake. Obviously, if there were any rotative motion in the wake of the ship, such as might be caused by a particular form of bossing or by the direction of rotation of the propellers, the rate of revolution would be affected and the speed in the open correspondingly changed. From this it appeared that the pattern ship, from which the W_P values were taken, must be similar in all respects if the results were to be reliable. Messrs. Denny's method was to try the models of ship and propeller in correct association, with every detail as closely reproduced as was possible with the means available. Whatever the wake might then be, and whether it were measured or not, the shaft horse-power and revolutions required were directly ascertainable. Failing these facilities, the propeller designer would be glad to avail himself of the method proposed by Admiral Taylor for estimating the wake factor for the particular design of ship, so that he might obtain the speed in the open, and be in a position to calculate shaft horse-power from the curves for standard three- or four-bladed propellers run in the open, given in Figs. 3 and 4 of the paper. It must be borne in mind, however, that there were wide limits of variation in what might be called normal designs—as shown in Figs. 1 and 2—and that special cases might vary much more widely than those shown, owing to directive action of hull or shaft bossing on the stream-line flow to the propeller. To the foregoing Sir Archibald added that he presumed the author was dealing with the face pitch, which was not necessarily the true pitch; they were, however, identical at about 1¼ pitch ratio. Fig. 4 of the paper served to show the extent of the error which might arise in estimating wake, but as internal-combustion engines usually ran at higher speed than the older reciprocating steam engines, the pitch ratio was likely to be smaller with the former, and the error consequently less serious.

Mr. W. J. Luke, who followed, referred to the time when the information given by Froude was all that was available in this country. The author's experiments, published in 1904, came as a revelation. The results were put into the form of Froude's R and D curves, and the speaker had analysed trial results to see how closely they could be reconciled with tank experiments. On an average, he thought, satisfactory agreement had been obtained in about 7 out of 10 cases, but the analyses had been made on the slip basis rather than the wake basis. He therefore welcomed any other method of approaching a very difficult problem. At first sight, however, the author's method seemed to be simply a matter of algebra and did not appear to differ fundamentally from what had been done in the past. In conclusion, he wished to suggest that the author should add in an appendix to the paper some further explanation of formula (1), which would be of considerable value to students and others not having the necessary information to hand.

The next speaker, Mr. H. G. Williams, said the author proposed to use a factor W_P, which he called the wake propeller coefficient to cover the wake factor, scale effect and all the other known and unknown corrections which had to be made in applying model results to full-size ships. The speaker welcomed the suggestion and would give it every possible trial. In analysing trial results he had almost invariably found the delivered horse-power to be far less than the engine shaft horse power, and, in propeller design, he, therefore assumed a loss of at least 20 per cent. between the engine and the screw. This generally gave good results, and was equivalent to using a correlating factor like the author's W_P. He would like to know why Admiral Taylor started with the delivered horse-power instead of the shaft horse-power, the latter, he thought, being the more reliable.

Mr. M. P. Payne, who continued the discussion, said the part of the paper which he found of special interest was that dealing with the comparison of wake coefficients of models with those of ships. It had, of course, been known for many years that the wake coefficient for the ship must be less than that for the model, but he had not previously seen the relationship stated quantitatively. As long ago as 1882, the late Mr. R. E. Froude had made some experiments on the subject in the old tank at Torquay. The model was of a liner and the conclusion reached was that the ship wake was about 5 per cent. lower than that of the model. This was in fair agreement with the figures quoted in the paper, when it was stated that the value of $\frac{k}{1-w}$ for ships averaged about 94 per cent. of that for the model. Actually, the agreement was even closer than might appear if, in the approximation leading up to k, the difference between 100 and 101½ were not ignored. The author had shown that the discrepancy of about 5 per cent. in the wake need not make much difference in the efficiency, but, for a given diameter, the pitch should be somewhat increased.

Dr. E. V. Telfer, in the course of his contribution to the discussion, said it was difficult to see why the wake for the ship should be less than for the model. He suggested, in this connection, that more attention should be paid to the lack of pressure similarity between the ship and model propellers, adding that if we assumed that the effective density of the ship water was 95 per cent. of the model water, we could square our ideas on propeller action. He also called attention to the fact that the author had assumed a constant mechanical efficiency for all the engines in dealing with trial results, whereas experience showed that at one-third load the efficiency might fall to 73 per cent., although it was 93 per cent. at full load.

The next speaker, Professor J. J. Welch, after expressing appreciation of the author's work, remarked that Table II and the curve for W gave a good method of obtaining the diameter and pitch for any new design. Propellers, he added, were usually designed by Froude's curves and, in a certain case he had already analysed, he was pleased to find that, at the best efficiency the difference between the Taylor and Froude methods amounted to only about an inch in diameter and the same in pitch.

Mr. S. V. Goodall asked for a little further explanation of Tables I and II in the paper, and remarked that, while serving under the author, he had been able to compare British and American propeller formulæ and tank experimental methods, and had found them to be in good agreement. He thought that, at Washington, wake results were obtained with the appendages fixed, but at Haslar they were deduced from the model without appendages. He was greatly impressed with the care taken in carrying out trials and with the amount of data collected by the author. His results were doubtless justified by more trials than were actually given in the paper.

The last speaker on this paper was Mr. A. W. A. Cluett, who, in the course of his remarks, said the constancy of k, as deduced from Table III of the paper, was remarkable. It would be useful if the value of k for each of the cases given in Figs. 1 and 2 could be supplied, together with the model value of $\frac{1}{1-w}$, in order to ascertain whether the constancy existed generally as in the eight cases given. Referring to Figs. 1 and 2, it would be seen that the two mean values for W_P were very similar, and that, for a single-screw, a fairly uniform excess of 0·30 existed over the twin screw, which was rather high. The small scale upon which W^P was shown, to some extent, veiled the large variation of many of the values from the mean, although, as the author stated, the majority of them were within 10 per cent. of the mean. For accurate working, however, even that variation was too great. The determination of W_P was easily carried out if the curves of Figs. 1 and 2 were used for a new design and the possible error accepted. In any case, if isolated results were taken, even for precisely similar ships, misleading values were likely to be obtained. After mentioning the various sources of error in the determination of W_P, Mr. Cluett pointed out that it would be seen from Table I that C_P varied with the slip and thus, S_w should vary also. These would affect the value of d by a percentage one-sixth as great as their own variation. It would therefore be possible, without much sacrifice of accuracy, to accept a mean constant value of W_P for twin and single-screw ships and a mean value for S_w, and then to calculate d from the known values of P, V, R, and a. This view, he said, was supported by the large permissible variations indicated in Fig. 5, where the effect of the variation of W_P was shown. Fig. 5 also showed that efficiency was very sensitive to variations in W_P, which emphasised the necessity for reliable data and the utility of tank results.

Owing to the time occupied by the discussion on this paper, the author's reply, which was then delivered, was made rather hurriedly. In the course of his remarks, Admiral Taylor said that one purpose of the paper was to make use of the laws of variation obtained from experiments with models and apply them to propellers with different characteristics. On the question raised by Sir Archibald Denny as to the pitch used, Admiral Taylor said, while the virtual pitch was used in Great Britain and was also used in the United States by aeronautical engineers, it depended on so many factors that complications arose. It was necessary to know the face pitch in making a propeller and he thought it better to employ that. With regard to the analysis of propeller results made by Mr. Luke from the speaker's paper of 1904, his own results had been even less satisfactory than those obtained by Mr. Luke. He agreed with Mr. Williams that it was preferable, where possible, to use thrust horse-power, but one objection to the latter was that the efficiency varied, depending upon the propeller. He would be glad to give the further explanation of equation (1) and of Tables I and II as requested by some of the speakers, and said, in answer to Dr. Telfer's remarks on the matter of mechanical efficiency, that it had been taken as constant. Of the 150 trial results given in the paper, however, very few had been progressive trials, the results being mostly represented by single spots.

Form Resistance and Skin Friction.

After thanking Admiral Taylor for his valuable paper, the chairman called on Mr. W. G. A. Perring to read a paper entitled "Form Effects and Form Resistance of Ships," adding that the report of the Skin Friction Committee of the Institution would be discussed with it. We propose to reprint the paper in abstract in a subsequent issue, but an abstract of the report will be found on page 464. Mr. Perring's paper gave the results of some experiments carried out in the William Froude National Tank in connection with the Post-Graduate Research Scholarship awarded to the author by the 1851 Exhibition Commissioners. Experiments were made to measure the pressure on a submerged body of mathematically calculable form, the results of which are given in one section of the paper. A subsequent section discussed skin and form resistance in the light of previous experiments, and others dealt with experiments made on a series of sharp-ended symmetrical models derived from the mathematical form and with experiments carried

out on more normal ship forms. The final section contained notes on model forms and the influence of certain features on the skin and form resistance, and also dealt with the application of the results to ships.

Invited by the chairman to open the discussion on the paper and the report, Mr. G. S. Baker referred first to Mr. Perring's work, remarking that the part dealt with in the paper represented about half the total work done. He hoped that next year the remainder of the work on skin friction, dealing particularly with a plank, might be brought forward. Referring to the report, something like 80 per cent. of the resistance of a ship was based on estimate, the tank only working on the remaining 20 per cent. in order to effect a reduction. Perring's work, and that done by Kempf in the Hamburg tank, were fairly clear evidence that our knowledge of the frictional resistance of a ship was inadequate, and he therefore hoped the Institution would see that the suggestions contained in the report were followed up. It was about ten years since he had first suggested that the work should be done and he thought the only way to do it was by full-scale experiments. It was certainly difficult, although not outside our capabilities, and if not done by this country it would be by some others. Research in this country was not making much headway at the moment, but unless progress were made it would be a serious matter for British shipbuilding.

The Secretary then read a contribution to the discussion by Mr. Summers Hunter, in the course of which it was suggested that towing experiments might also be carried out with certain types of cargo boats. He referred to the comparatively small percentage of cargo boats built for which model experiments were carried out, although material improvements in the propulsive efficiency usually resulted from such tests. In conclusion, he appealed for more adequate financial support for work of the William Froude National Tank.

The discussion was continued by Mr. M. P. Payne, who, after criticising the investigations of pressure distribution on submerged bodies given in Mr. Perring's paper, expressed his appreciation of the fact that the subject of skin friction had been considered worthy of inquiry by a Committee of the Institution. The need for further experiments, he thought, was clearly brought out in a paper by Mr. Frodsham Holt, read before the Institution in 1920. Mr. Holt had shown that the actual measured thrust from the screws of certain vessels departed considerably from the calculated thrust or the computed resistance, unless a thrust-deduction factor, much higher than was justified by model experiments, was assumed. As a further example of the need for increased knowledge on the subject of propulsion, he mentioned that the efficiency of propulsion, as far as H.M. ships were concerned, appeared to be much lower at the present time than it was some 25 years ago. It might, he added, be a fact that the resistance of modern vessels was greater than was attributed to them, but it would be worth while to carry out experiments in order to determine if this were the case or not.

Rear-Admiral D. W. Taylor, who was invited to speak by the chairman, said that at the beginning of the century, Froude's results were accepted without question, but his methods did not apply satisfactorily to the enormous vessels which were now built. The present position was that almost every nation and every tank tended to develop its own coefficients, but what was required was something which would replace Froude's results and be universally accepted.

The only other speaker in the discussion was Dr. E. V. Telfer, who remarked that in the last few years we had become less dependent upon ship model experiments, and had tried to obtain more information from aeronautical research work. He was interested in the part of Mr. Perring's paper relating to the effect of small errors, having himself made a similar analysis some three years ago, and come to the same conclusions. He was afraid, however, that it was not possible to have a skin-friction error without a serious error in the total resistance. He also asked Mr. Perring to give the wetted surface of the models used in his experiments. In connection with the report of the Skin Friction Committee, he thought Froude had been astonished at the manner in which skin friction became steady after a length of 50 ft. Kempf had started out with that in mind, and it was more important to have proved that this specific resistance was constant up to a length of 61 metres than to say that there was still a big gap to be bridged. He thought we should now be satisfied that Kempf's results had established the constancy of the specific resistance, and that if any further work on skin friction were done it would be better carried out in a tank than by experiments on a destroyer.

Mr. Perring, who was then called upon to reply, said the discussion referred mainly to the report and he was unable to reply for the Committee. In answer to Mr. Payne, he gave further particulars of the pressure measurements referred to, and to Dr. Telfer's request for particulars of the wetted surfaces of the models, promised that these should be included in an appendix to the paper as printed.

METHOD OF INCREASING SCREW-PROPELLER EFFICIENCY.

Owing to the lateness of the hour, Mr. W. Pollock, whose paper, entitled "A Suggested Method of Increasing the Efficiency of the Screw Propeller," was the last item on the programme for the morning session, contented himself by showing a number of models illustrating the design and construction of the Star contra-propeller to which the paper mainly relates. We commence to reprint abstract of this paper on page 459 of this issue.

The first speaker on the paper was Mr. Andrew Hamilton, who pointed out that the improvements obtained in practice were not so great as were obtained in tank experiments. It was difficult, he said, to get exactly similar conditions in different voyages, but he stated that, in the case of a ship 400-ft. by 52-ft., a speed of 11·2 knots had been maintained on a voyage of 11,000 miles, and that the speed on a previous voyage was 10·8 knots. In three subsequent voyages with the contra-propeller, the speeds maintained were 11·4, 11·4 and 11·24 knots, so that the gain in speed due to the contra-propeller appeared to be about 0·2 knot. Weather conditions, however, affected the results, and it was difficult to say to what extent. He thought that if the guide blades could be fitted forward, as in Fig. 6 of the paper, it would be better than the arrangement he had been using, and suggested that further tank tests should be carried out to elucidate this point.

Mr. J. Tutin, who followed, said a contra-propeller fitted behind the main propeller differed fundamentally from one fitted in front. When fitted behind, it could not affect the efficiency of the main propeller and might, or might not, develop a separate thrust, whereas when fitted in front it might affect the efficiency but would certainly develop a separate resistance. The mathematical analysis given in the paper applied only to the case of a contra-propeller behind, and he wished to know whether model experiments indicated a definite improvement for both types; if so, he asked, what was the actual gain? He thought the statement in the paper to the effect that the contra-propeller was a protection to the main propeller was difficult to reconcile with another, mentioning that a steamer, working in ice, had been found to have a piece chipped off the main propeller while the contra-propeller was undamaged. Mr. Tutin also criticised some points in the notes on propeller theory based on Professor Föttinger's work and given as an appendix to the paper.

The next speaker, Mr. Hamilton Gibson, pointed out that the most effective part of a propeller was the outer area near the tips of the blade, and that, as the roots of the blade were approached the churning effect increased, the water being carried round more or less instead of being directed aft. The fixed contra blades, he said, were only about half the length of the rotating blades, and thus made use of the churning action.

Sir Archibald Denny, continuing the discussion, said he had carried out model tests on two designs of contra-propeller and had found no advantage; the same results, he added, had attended the fitting of the device on a motor launch and on the steam yacht Snark. He noticed that, with contra-propellers, the rudder post was shaped or washed off, and as there was considerable gain by sharpening the rudder-post that might have some effect. He, however, had not been able to find any advantage whatever.

The last speaker, Mr. A. W. A. Cluett, said that, from considerations of the motion of the water in the propeller race, it was probable that the most efficient part of the contra-propeller would be that near the boundary of the race. The blades should, therefore, extend to this part, whereas, according to the paper, they were made only 55 per cent. of the diameter of the propeller. The angle of the blades should also vary at different radial distances to suit the direction of the flow, and this feature did not appear to be possessed by the Star contra-propeller. He thought the greatest effect of the latter could be obtained at high slips, and mentioned that experiments made at Haslar some ten years ago showed a loss at low slips and a gain when the slip was in the neighbourhood of 45 per cent. In the latter case the gain in horse-power amounted to about 5 per cent., but a high slip indicated a low-efficiency propeller. He asked if the author would include the results of the experiments made in the Hamburg tank, as these would be instructive on this point. Finally, Mr. Cluett pointed out that while the aperture of a single-screw ship lent itself to the accommodation of the contra-propeller, it was not easy to obtain an effective practical arrangement in the case of a twin-screw vessel.

On being called upon to reply, the author remarked that it was difficult to do so in the brief time available. He wished to point out, however, that the trials referred to by Sir Archibald Denny had been made 12 years ago, and that the design of the Star contra-propeller was now quite different. The results referred to in the paper, were obtained with an improved form, which had proved more effective than those designed only four years ago. He hoped to obtain further particulars of the trials made by Messrs. Denny, and would then reply more fully. To the other points raised in the discussion, he would reply in writing.

The Chairman, after thanking Mr. Pollock for his paper, adjourned the meeting until the afternoon.

STRESSES IN CLAMPED PLATES.

On Thursday afternoon the chair was occupied by Sir John Harvard Biles, who called upon Professor C. E. Inglis, of the University of Cambridge, to present his paper on "Stresses in Rectangular Plates Clamped at their Edges and Loaded with a Uniformly Distributed Pressure." This was a paper, entirely mathematical in character, which dealt with a problem of great practical importance to the designer of ships. The problem of clamped plates had, said the author, hardly received the consideration which it deserved, and he had undertaken an investigation to find what degree of accord there was between the results obtained by the application of Grashof's empirical equation and those derived from the fundamental differential equation deduced from the laws of elasticity. It was found that results derived from Grashof's formula for the deflection, exceeded the calculated value by 12 per cent. in the case of square plates. Experimental work done by Mr. W. J. Crawford in 1912 led to the conclusion that the equation for the stresses propounded by Grashof in a square plate, should have the multiplying constant 1·25 introduced, and this conclusion was borne out by the analytical investigation. When dealing with the case of a plate which had one side of twice the linear dimension of the other, the Grashof deductions were found to be very close to those found theoretically.

Mr. C. E. Stromeyer opened the discussion by stating that although finality seemed to have been reached in dealing with the subject of the stresses in the plating of ships, it would quite likely be found that there were still other problems for which this analytical investigation would prove a starting point in the obtaining of solutions. He had analysed the results of some experiments on stayed plates on the basis of the fundamental equation, given in an appendix to the paper, dealing with this case, and

found the results to be not in absolute agreement. For the case of clamped plates it was of great moment to engineers and shipbuilders that they had now got the information they sought and that the experimental work was fully confirmed by theory.

Professor Klinoff, in discussing the analytical investigation, stated that the problem had been regarded by mathematicians as so important and so difficult of solution that it had been a subject for which the Grand Prix of the Société Mathematique de France had been offered for many years.

Professor T. B. Abell called attention to the long series of experimental investigations of the subject, in many cases with very imperfect apparatus. In actual work perfect encastering could not be secured. The author had given in his paper sufficient information to cover all the cases coming under the consideration of the naval architect. Putting the ultimate derivations into the common types of expressions they used, it had been shown that they should use $\frac{W l^2}{12 \cdot 7}$ instead of $\frac{W l^2}{12}$. It was very useful to know that they could take the stress results for a plate of ratio of sides 2 to 1 and use them for other proportions.

Sir James B. Henderson commented on the great advantage to people who had to deal with the problems from a practical point of view that the results of the analysis showed that the Grashof formula could be used, as it was in good agreement with the derivations. This was a good example of the type of work that could be done by an engineer on questions relating to the theory of elasticity. Without the combination of the characteristics of both the mathematician and the engineer in an investigator, it would be necessary to obtain closer co-operation of men of the two types in dealing with problems of great importance to the practising naval architect and engineer.

Professor J. J. Welch said that the work of Professor Inglis had emphasised the small effect of end fixings with plates of which one side was twice the length of the other. It was usual to look upon a plate in a ship as a beam fixed at the two ends. The bending moment obtained from study in that way was practically the same as was obtained with the 2 to 1 plate. Making comparisons of cases taking the centre line and edges of a plate, the values of the constants for the determination of actual flexual couples in any case, were 0·04116 and 0·08293 by this analysis, and 0·0416 and 0·0833 by the simple beam method, respectively. In plates of greater ratios of dimensions than 2 to 1, the maximum stresses could be obtained with the simpler beam formula. In the plates used in actual practice the bending moments at the edges and the middle approximated to the same values. The value of the work of Professor Inglis was that they were now able to trace the variations of stress over the entire plate.

Mr. Payne then read a communication prepared by Mr. F. Bailey, R.C.N.C., in which he stated that he had recently completed an investigation similar to that given by Professor Inglis. His method was to consider an infinitely long plate of finite breadth clamped along the two edges, and subjected to uniform pressure on one face. On the opposite sides he assumed a series of equal loads on lines equidistant from each other, and at right angles to the long edges. One distribution of loads just annulled the deflection of the plate produced by the uniform pressure. When this was found they had what was truly a series of rectangular panels of plating, each clamped at the four edges, and subjected to uniform pressure. The results obtained were in close agreement with those of Professor Inglis for the cases he had dealt with. They also showed that for practical purposes the 2 to 1 ratio plate could be regarded as of infinite length.

In reply Professor Inglis said that the discussion showed that experimental work received consideration before theory, but a true understanding of the actions was essential. Mr. Stromeyer had referred to the case of stayed plates and the lack of absolute agreement between theory and experimental work. Further investigation of this case would, he hoped, be undertaken.

Rolling of Ships.

Sir John Biles then announced that in the absence of Mr. G. Vedeler, who had submitted a paper on "Notes on the Rolling of Ships," they would take that paper as read and discuss it jointly with the next. This paper was later epitomised by Professor J. J. Welch. It dealt with some theoretical results obtained by mathematical investigation of rolling in still water and among waves.

Mr. H. J. R. Biles, a former Sir William White Post-Graduate Research Scholar of the Institution, read his paper on "Model Experiments with Anti-Rolling Tanks." This will be reprinted, abridged, in a future issue of ENGINEERING.

Mr. Lloyd Woolard, who opened the discussion on the two papers, said he had been asked to submit a contribution by Mr. W. J. Berry, Director of Naval Construction. In this it was stated that the results obtained with the apparatus described by Mr. Biles threw some light upon the effects of water tanks on rolling. Experience showed that the minimum height of waves for which tanks were effective was about 40 ft., whilst the length did not often exceed 600 ft. With a 3 deg. maximum effective wave-slope the height for a 400-ft. wave was only 10 ft., and it was considered that very useful information could be obtained by extending the experiments to cover these greater slopes. The 12-deg. slope, referred to in the paper, represented a height of 40 ft. on a 600-ft. length. It was noted that tanks were only effective for regular waves of about 700 ft. to 1,800 ft. length. The waves most frequently met with were those of about 600 ft. or less, and therefore tanks would prove detrimental rather than useful under most conditions. Tanks had been tried in H.M.S. Conqueror and King George, and were found to be of little value, and as the space they occupied was required for other purposes during the war, they were removed. Trials were again in contemplation with H.M.S. Vivian. The irregular waves met with at sea were likely to be non-trochoidal, and the conditions of the experiments might not be far from those possible under the actual conditions at sea. In the paper it was stated that the model rolled on the average in the period of the wave, which conflicted with experience on ships, where it was found that these rolled approximately in their own period in irregular waves. It was worthy of consideration whether the modified Frahm anti-rolling device was capable of being tested on a model, but conditions might prove difficult of accurate representation. It was interesting, concluded Mr. Woolard, to note that after 12 years, experimenters had come forward and shown that there were no great errors in his own theoretical paper, given that length of time ago.

Mr. Maurice Denny then asked if they really knew what they wanted to do with their ships in regard to rolling. Dr. Vedeler had said that if an easy rolling ship were wanted the centre of buoyancy must be near the centre of gravity. The naval architect had a difficult problem to contend with in giving effect to this proposition. There were other problems of more importance than rolling for which there were penalties that were much more severe. He was pleased to be able to have the privilege of hearing the excellent paper by Mr. Biles, who was now a member of his firm's scientific staff.

Mr. M. P. Payne pointed out that when a ship rolled the surrounding water was set in motion and constituted a virtual mass which had to be added to that of the ship. It was considered that it was more correct to regard the motion of the water as constituting a virtual increase of moment of inertia, if it could be assumed to be constant in its effect throughout the period of roll. That would be strictly the case for a body immersed in a perfect fluid with no free surface, but it could only be conjectured to what extent the effect of the motion of the water surrounding a rolling ship could be taken as a constant addition to the ship's moment of inertia. In Mr. Vedeler's paper and some others of recent date, references were made to virtual mass effect and also to the speed of drift of ships under these conditions. No figures, however, were given to indicate the probable magnitude of these. In some experiments at Haslar with a model, they had found that when it was exposed broadside to regular series of steep waves of periods of 1·2, 0·9 and 0·7 seconds, the speeds of drift to leeward were 14 ft., 28 ft. and 23 ft. per minute respectively. The speeds were higher than was anticipated, but that was possibly due to the shallow draught of the model.

Dr. A. M. Robb said the fundamental fact disclosed by the experiments was that anti-rolling tanks demanded greater consideration than they had received. The possibility of synchronous action had to be watched. The anti-rolling tank was most effective when the period was less than that of the ship. In one of the tests there was evidence that the waves might have been splashing against the top of the tank.

Mr. H. J. R. Biles, in reply, said there was an uncertainty shown by the contributors to the discussion as to whether a ship rolled in her own period or that of the wave. He hoped to deal with the individual points brought up, when he had the full context of the contributions, but he agreed that in the case cited by Dr. Robb some splashing did occur, but not over the entire length.

The Chairman then concluded the proceedings by calling for votes of thanks to the authors of the papers and adjourned the meeting until the evening.

Marine Oil Engine Trials.

At the Thursday evening session, Engineer Vice-Admiral Sir Robert B. Dixon, Engineer-in-Chief of the Royal Navy, was in the Chair, and after referring to the formation of the Marine Oil Engine Trials Committee and the work they had undertaken, called upon Mr. W. H. Patchell, the Deputy Chairman of the Committee, to present the Report dealing with the trials of M.S. Dolius. We have already reprinted the report, as far as the test results are concerned, in ENGINEERING (see pages 397 and 434 *ante*), and have dealt with the discussion at a meeting of the Institution of Mechanical Engineers (see ENGINEERING, March 27, 1925, page 391). We have also described the essential features of the Scott-Still engines installed in the Dolius (see ENGINEERING, vol. cxvi, page 639), and have reprinted an exhaustive paper, which Mr. Archibald Rennie read before the Institution of Engineers and Shipbuilders in Scotland, on the details of their construction (see ENGINEERING, vol. cxiii, pages 275 and 309).

Mr. W. H. Patchell, in presenting the Report, said that in undertaking this test-work, they were really continuing the work done by the Institution of Mechanical Engineers on the trials of steam engine driven ships, which was performed in 1889 and 1890 on which, in addition to the separate reports, they had had a discussion on all the tests together, after the presentation of a report on the conclusions arrived at from them, in 1894. It was hoped to perform similar valuable service in connection with the modern developments in Diesel engines for ship propulsion. In the report, all the essential results were provided from which deductions useful to the designers could be made. Nothing but simple experimental facts were given, and so far no inferences obtained from them had been incorporated in the report, except the simple arithmetical deductions of such matters as power, fuel consumption and efficiencies. In addition to the tests on the Sycamore with Richardsons-Beardmore-Tosi engines and those on the Dolius with Scott-Still engines, the Committee had also conducted trials on the Werkspoor engine, the Doxford engines of the British Trader and the Fullagar engines of the British Aviator. These would be published in the immediate future.

Mr. James Brown, of Scotts' Shipbuilding and Engineering Company, Limited, the builders of the Dolius, opened the discussion by stating that this report, compared with the first report on the trials of the Sycamore (see ENGINEERING, vol. cxviii., pages 750 and 784), gave more information, as a progressive series of speed trials was carried out at sea. In these tests the ship was not fully laden, but the propellers were well under water. These tests were, therefore, of a ship as well as of an oil-engine. Enhanced value was given to the results because a model of the ship was tested in the National Tank, and the effective horse-powers were derived

from the tests. These were available for comparison with the results obtained at sea. It would be seen that the ratios of E.H.P. to I.H.P. and E.H.P. to B.H.P. worked out as 0·536 and 0·608 respectively, results, which though not abnormal, were very satisfactory and indicated the efficiency of propulsion as very good. The B.H.P. deduced from the oil used and from the I.H.P. and frictional tests were in substantial agreement, and when it was remembered that the former referred to the brake readings on the test bed, it was impossible to accept any less substantial figures in their place. These, with the readings of the thrusts, formed a useful field for investigation, and it was hoped that the analysis to which they would be subjected would lead to a reconciliation between the engine, propeller and ship performances.

Mr. Brown then referred to the heat-exchange system of the engine, and stated that in one case the temperature at the boiler water drum was 344 deg. F. and the return from the cylinder jackets 349 deg. F. The pressure recorded in the drum was 116 lb. per square inch, and the corresponding saturation temperature was 348 deg. F. The sensible heat was therefore no measure of the heat picked up by the water. The report showed the amount of sensible heat recovered by the feed heaters from the exhaust gases, deduced from the change of temperature of the feed water. It would be seen that the temperature of the feed leaving the heater was 342·3 deg. F., or only 5 deg. F. below the evaporation temperature. It seemed probable that more heat than that deduced was obtained, and the examination of the heat lost by the gases bore this out. As the amount of steam passed to the blower turbine was out of control, except by burning oil under the boilers, the power of the turbine could only be varied by changing the inlet pressure, and this could be done on the Dolius by opening or closing nozzle valves on the inlet side. When these were opened the pressure would fall. It must be regarded that the fuel consumption was satisfactory, as this was the first engine, and it could be improved, so that even better consumptions might be anticipated.

Engineer-Commander H. B. Tostevin, R.N., commenting on the statement that 18 per cent. more power was obtained from the engine through introducing a heat-recovery system, at an expenditure of 12 per cent. additional weight, said that certain parts of the weight of the main engine should be included, and suggested that the main blower weight had not been considered. The mechanical efficiency obtained appeared to be rather high. He was prepared to believe that it might be 88 per cent. If the brake horse-power was correct, which was quite likely, the indicated horse-power must be low. The connection to the indicator seemed to be small, but, in referring to this, he gave some figures of tests with an engine running at 375 r.p.m. When a $\frac{3}{8}$-in. diameter pipe 4½ in. long was used the maximum pressure obtained was 96 lb. per square inch. Replacing this by a ½-in. pipe made no effect, but a similar pipe 8 in. long caused an error of 8 per cent., while a bore of ⅝ in. and 6 in. length gave a change of 10 per cent. It was seen that large changes were necessary to cause any appreciable effect. He wondered if there was any error due to the phasing of the indicator motion through the use of long cords; with lengthy connections there might be errors due to stretching. In these ways a small trouble might cause a considerable error. An explanation was required of the torsionmeter results, as they did not tally with the brake horse-power. The error might be due to the shaft not having a modulus of rigidity of the commonly accepted value. He supposed that the shaft was not disconnected when the zero of the torsionmeter was checked, and that might be a source of trouble. Tests should be made of the torsionmeter between the engine and the brake.

Mr. E. W. Moullin referred to the means taken to calibrate the torsionmeter and said that in one set of tests it was found that the readings of the torsionmeter were high compared with the brake horse-power results, and low in another. It was impossible to believe that both these conditions could be obtained with the instrument, if it was faulty. The discrepancy of the results was not due to any variation in the modulus of rigidity, but he could not say if there was any initial stress on the shaft. The ship was at rest when the zero was checked. Seeing that it came back to the same position at the end of the run, it was not possible to believe there could be any fault.

Mr. W. J. Still, in opening his remarks, stated that the Dolius in a recent run from Shanghai to Hong Kong behaved well and gave no trouble. The speed was 11·6 knots and the oil used per day of 24 hours was 8·6 tons. The main characteristics of the Still engine were, he said, shown by trials Nos. 8, 9 and 10. These indicated that the work expended in overcoming friction and the scavenge air resistances was balanced by energy provided from heat usually wasted in internal-combustion engines. Considered in this way the combustion horse-power became the shaft horse-power and the fuel consumption of 0·353 lb. per combustion horse-power during the tests became 0·354 lb. per shaft horse-power. The Dolius saved 2 tons of fuel oil per day over sister ships developing 2,000 h.p. This amounted to 20 lb. per horse-power for a 10 days' radius of action. They realised that the Dolius engines were far too heavy for naval service, but these were constructed irrespective of weight considerations, except as they affected first cost. As the Still engine equipment compared well with any commercial engine, there was little inducement to study questions of weight, and to cut it down at the expense of increased first cost was inadmissible. For naval purposes they had constructed an engine working at higher speeds. The test engine of this type had a single cylinder of 13½ in. bore and 22 in. stroke and developed 400 indicated horse-power at 360 r.p.m. He then showed a series of indicator diagrams obtained with this engine with mean effective pressures ranging from 24·5 lb. to 141 lb. per square inch. On completion of the Admiralty trials, the particulars of a six-cylinder engine of the same sizes of cylinders were got out, and the complete machinery weight of the installation, including boilers, auxiliaries, shafting and propellers was estimated at 85 tons. In this determination the weights of the engine parts, except the crank-case and bedplate, were obtained from the known weights of the single-cylinder set, whilst the boiler and condenser were standard Admiralty equipment. Taking the combustion mean effective pressure as 92 lb. per square inch, the value corresponding to maximum economy, for an engine running at 300 r.p.m. the weight of a 12-cylinder engine giving 3,000 shaft horse-power would be 63·5 lb. per shaft horse-power. The conditions specified might be regarded as those for cruising. If the combustion maximum engine pressure were raised to 124 lb. per square inch and the steam pressure increased by the burning of oil under the boilers, 5,000 shaft horse-power could be obtained at 363 r.p.m., and the weight per shaft horse-power would then be 38 lb. Even this has been exceeded for, on trial, the engine gave the equivalent of 6,000 shaft horse-power at 380 r.p.m., equal to a weight of 32 lb. per shaft horse-power. These results could be obtained with a consumption equal to that of the Dolius at full power—0·35 lb. per hour per shaft horse-power. The figures given showed the scope in regard to difference in weight obtainable by design and the employment of higher speeds, for the output per cylinder in the engines of the Dolius and this experimental one were practically the same.

While the 20 lb. per horse-power saving in the oil fuel which had to be carried for a 10 days' service, already referred to, was of little or no consequence with an engine weighing 700 lb. per horse-power it was of great significance, when that value was reduced to 38 lb. Some slides were then shown by Mr. Still to indicate that there was a limit to the increase of the combustion mean effective pressure, but there was scope for increasing the power by greater utilisation of waste heat on the steam side of the system.

Mr. W. G. A. Perring, referring to the torsionmeter readings, said he had most faith in the measured torque. The results deduced from the indicator diagrams were much too high. It was disappointing that the opportunity was not taken to test the torsionmeter when in dock. He asked if the indicators were calibrated.

Mr. G. S. Baker commented on the fact that the Dolius when tested was in a half-loaded condition, and not therefore as efficient as if deep in the water. The slip during the tests showed little variation, not more indeed than 1 per cent. Indicators demanded more consideration than they had received, and when it was suggested that 10 per cent. variation could be obtained in the same tests, it seemed necessary to call the attention of engineers to the question.

Engineer Lieut. Hext, R.N., then detailed his experiences on the maiden voyage of the Dolius, to which reference was made in our report of the proceedings at the discussion of the report by the Institution of Mechanical Engineers (see ENGINEERING, page 391 *ante*).

Sir Thomas Bell spoke of the results of the trials of the Dolius, as affording a successful example of how much heat can be saved by a recovery system. There were some matters to be cleared up regarding the various results obtained from the indicated, brake, and shaft horse powers and those of the torsionmeter, but he thought there was little reason to doubt the accuracy of the observations as had been done by Mr. Baker in regard to the indicated horse-power.

Mr. C. W. J. Taffs testified that the torsionmeter came back to its zero on stopping. He suggested, however, as a possible source of error, actions due to centrifugal force on the choking coils in the instrument.

Mr. Buckler commented on the great length of time which elapsed between the completion of the trials and the publication of the reports. Might it be the case, he asked, that the torsionmeter was fitted at or near a node in the shaft.

Mr. E. W. Moullin then answered the question of Mr. Taffs by stating that in his tests of the 400 h.p. torsionmeter at 1,700 r.p.m. he had found a centrifugal error of 3 per cent. at the full load torque. The action was proportional to the square of the speed and he, therefore, concluded that at 130 r.p.m. the effect would disappear from any reasonable consideration.

Mr. Still referred to the fact that steam trials were run to determine the frictional losses, and the brake horse-powers at full loads, determined from their use in association with the indicated horse-power, were in accord with the values obtained in actual test.

Mr. W. H. Patchell after commenting on the free and open nature of the discussion which the report had aroused said that with their present small staff it was impossible to get the work of preparing the reports carried out any faster.

Engineer Vice-Admiral Sir Robert Dixon then closed the proceedings by thanking Mr. Patchell for presenting the report, and the contributors to the discussion for the points they had raised.

(To be continued.)

BOILER FEED WATER.—The supply, softening, and control of boiler feed waters used in colliery practice is discussed in a concise and instructive manner in Bulletin XVI, 1925, entitled "Boiler Feed Water," published at a price of 2*s.* 6*d.* net, by Messrs. H. F. and G. Witherby, of 326 High Holborn, London, W.C.2, for The Lancashire and Cheshire Coal Research Association. The impurities usually contained in the waters available at the pit-head and in nearby streams are described, together with the means, both chemical and mechanical, adopted for eliminating them. Hints on desirable features of water softening plant with particulars of the principal types available, follow; whilst an account of hardness and alkalinity tests and tables of boiler scale analyses and solubilities assist in enhancing the value of this useful little book.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS.—Volume lxx. of the Transactions of the American Institute of Mining and Metallurgical Engineers has lately been published. It contains the papers presented and discussions which took place at the meeting held in New York in February of last year and at that of the Petroleum Division, held in Tulsa, Oklahoma, four months previously. Among the many contributions which the Transactions contain, those entitled "Trend of Prices in the Petroleum Industry," by Mr. Joseph E. Pogue, and "The Law of Supply and Demand," by Mr. Arthur Knapp, together provide a good analysis of the factors operating to bring about the present fluctuating position of the oil industry. The volume is issued from the offices of the Institute, 29, West 39th-street, New York.

THE ALCO STEAM TRAP.

ADRIEN LEGRAND ET CIE., ENGINEERS, GLAGEON, FRANCE.

Fig. 1.

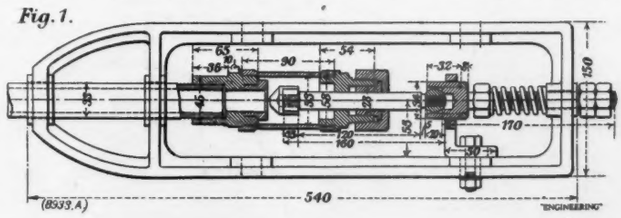
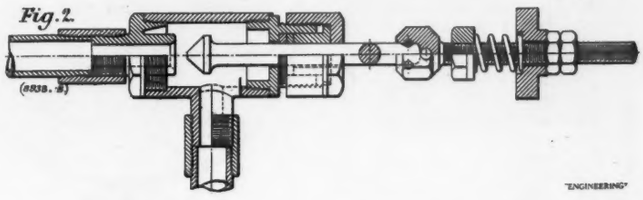


Fig. 2.



THE ALCO STEAM TRAP.

In Figs. 1 and 2 herewith we illustrate an ingenious and remarkably simple steam trap which has been introduced by Messrs. Adrien Legrand et Cie., of Glageon, Nord, France. The trap is quite automatic, and depends for its action upon the expansion and contraction of a length of piping leading to the trap. The accumulation of any appreciable quantity of water of condensation in this pipe has the effect of cooling it, and it therefore contracts. One end of the pipe is attached rigidly to a fixed point, and on to the other is fitted a valve seating. The contraction of the pipe therefore results in the withdrawal of the seating from a valve, which is attached to a second fixed point, and the water of condensation is then ejected from the length of piping by the boiler steam. As the water is replaced by live steam the temperature of the pipe rises and its re-expansion due to this cause automatically re-seats the valve.

The design and construction of the trap will be clear from Fig. 1, which illustrates the arrangement adopted for high-pressure steam, but to follow out the action it must be understood that the length of pipe entering the valve box at the left-hand end is rigidly attached to the engine room wall, or other convenient fixed point, at a distance of some 6 metres from the valve box itself. From Fig. 1 it will be seen that the end of the pipe carrying the box is free to move through guides in a frame on which the valve proper is mounted, and this frame, in turn, is bolted by suitable lugs to the engine-room wall. If the valve were rigidly attached to the frame it will be evident that it would only be tight at one particular pipe temperature, and that if this temperature were exceeded for any reason the holding down bolts would be sheared, or the apparatus damaged in some other way. For this reason, the valve is held up by the spring shown, which not only eliminates the possibility of damage from this cause, but, by suitable adjustment of the length of the spring, allows the valve to follow the seating for a short distance when contraction occurs. This permits a certain accumulation of water before the valve opens. The strength of the spring is sufficient to hold the valve on its seat against the steam pressure. The loss of steam which occurs during the process of ejecting the water is claimed to be negligible. The branch pipe by means of which the water escapes to a sump is not shown in the figure, but the arrangement is similar to that shown in Fig. 2. The latter illustrates the construction adopted when the trap is required for use with low pressures. The frame is not shown in this drawing but it is generally similar to that used with the high-pressure type. The agent for the trap in this country is Mr. T. H. Gore, of 360, Upper Richmond-road, S.W.15, and the frame can be supplied with various alternative lug arrangements for wall, ceiling, or floor fixing. Groups of traps in one frame can also be supplied if desired.

OPEN EXHIBITIONS IN ENGINEERING.—It is announced that the Council of the University College of Southampton have decided to award two open exhibitions in engineering to candidates who may or may not be resident in the district. The awards will be made on the recommendations of the Board of the Engineering Faculty without formal examination, provided the candidates have matriculated and are prepared to study for a degree in engineering.

THE WATER-SUPPLY OF THE CITY OF ABERDEEN.*

By GEORGE MITCHELL, M.Inst.C.E.

THE City of Aberdeen (population 160,000) is supplied with water drawn from the river Dee, 20 miles west of the city. The old works, completed in 1866, consist chiefly of a 12,000,000 gallon storage-reservoir, 0·5 acre of slow sand filters, 18·5 miles of brick aqueduct with a capacity of about 8·5 million gallons *per diem*, service-reservoirs, and a hydraulic pumping-station. Unfortunately, this aqueduct has been a continuous source of anxiety. In the autumn of 1912, a slight enteric epidemic occurred in the city. This was at first believed to be water-borne, but it is now believed to have been milk-borne. It brought home to the Town Council the urgency of immediately improving the water-supply. A scheme, carried out to put matters temporarily on a safe footing, included sterilising the water by quick-lime, improving the storage-reservoir, and the construction of 2 acres of slow sand filters. The water-supply was limed from 1914 to 1916.

In 1916, the Town Council obtained powers to carry out a new scheme, estimated to cost 1,125,000*l.*, and the work was commenced in 1920. This scheme is designed to supply an estimated future population of 240,000 with 40 gallons per head per day. A new intake and screening-chamber and a 60-in. intake-conduit were constructed, also a 6-ft. by 3-ft. conduit leading to a new 24 million gallon concrete storage-reservoir. The walls of the reservoir were constructed in 30-ft. lengths, with joggled ends connected by steel plates. The asphalted floor is underdrained to prevent uplifting pressure. The reservoir is divided into four bays by means of reinforced-concrete baffle-walls. The outlet and by-pass pipes are 48 in. in diameter, and are of reinforced concrete. Three new filter-beds of a total area of 1·4 acre were constructed. These are of the ordinary slow sand type, but they are cleaned by squeegeeing instead of by scraping. It is believed that this system of filtration will be very suitable for a clear water like that of the Dee. It produces a thickened film less liable to rupture, keeps the sand of a constant thickness, and the filters ripen quicker. The filter-beds, when all in use, can filter the present average day's supply at the standard rate of filtration. From experience at Aberdeen and elsewhere, it is believed that most waters can be efficiently filtered at rates much exceeding the standard rate, and that the present area of filters will suffice for a long time to come. No additional liming plant was put down, and it is not intended to lime the water in the future. The old liming plant will be available as an emergency purification plant.

The new aqueduct has a total length of 17·4 miles. In conjunction with 9·6 miles of the old aqueduct, which will be reconstructed in the future, it will have a capacity of 14 million gallons *per diem*. In the first instance, however, it will have a capacity of about 11 million gallons. The western 2·7 miles and the eastern 5·1 miles will have a diameter of 46 in., and the central 9·6 miles will have a diameter of 38 in. There will thus be a flat hydraulic gradient at the ends and a steeper hydraulic gradient in the centre portion. As this aqueduct is essentially a single-line aqueduct with comparatively little reservoir-capacity at its city end, special precautions were taken in its design. For most of the length competitive prices were got for the construction of the pressure sections in cast-iron and steel pipes lined with concrete, and in reinforced-concrete pipes. All things considered, reinforced-concrete pipes proved to be the most expensive.

The water entering the aqueduct is measured by a Venturi meter of the water-column type. The section (0·7 mile), adjacent to the filters is a concrete conduit of horse-shoe section, 5 ft. 3 in. by 3 ft. 8 in. The next section (2 miles) consists of 48-in. steel pipes lined with $\frac{7}{8}$ in. of cement mortar applied by hand. There has been a long experience of similar pipes in America of somewhat smaller size. There is little apparent economy in using the cement lining, as, for the same cost, a larger unlined pipe could be provided having the same probable ultimate-discharging capacity. The cement lining, however, gives greater certainty as to the ultimate capacity, preserves the metal, is cleaner, and provides considerable additional stiffness.

The steel pipes are in 20-ft. to 25-ft. lengths, constructed of $\frac{7}{16}$-in. mild-steel plates, and were delivered without any coating. The outside was thoroughly cleaned and painted with one coat of bitumastic and one coat of bitumastic enamel, applied hot. The pipe-sockets were 4½ in. deep and were filled partly with hard-caulked cement mortar and partly with lead wool 1½ in. deep. The joints were tested by means of a tester covering the inside of the joint, into which water was pumped under pressure. The next section comprised 1·5 mile of 48-in. and 46-in. steel pipes, $\frac{5}{16}$-in. thick. These were coated outside with "mexphalte," and were given two wrappings of hessian cloth. They were lined with $\frac{7}{8}$ in. of cement mortar applied by hand. The depth of lead used in the pipe-joints in this case was 2¼ in. The last section of steel pipes let was the central section of 9·6 miles of 40-in. pipes. These are constructed of $\frac{5}{16}$-in. plates and were coated outside with "mexphalte" and hessian cloth. They were lined by the centrifugal process with 1 in. of 2-to-1 cement mortar. One-third of the pipes had the mortar mixed inside the pipes by spinning. In the case of the rest of the pipes the mortar was mixed outside the pipes, by a special machine. As compressed air was to be used on the works for other purposes, it was decided to test the pipe-line in lengths of about 0·2 miles by compressed air before the trench was refilled.

Three miles of the aqueduct consist of 48-in. cast-iron pipes lined by the centrifugal process with 1 in. of 2-to-1 cement mortar. Lead wire 2½ in. deep was used for jointing, the sockets being 3½ in. deep. These pipes also were tested by means of compressed air. It is essential in the case of large cast-iron pipes that not only the joints but the pipes themselves be tested in the trench before covering up. The stop-valves were of standard diameters, and were made nearly the full size of the pipes, as the fall available was very small. Automatic shut-off valves were fixed at two points. The air-valves are of the usual double-ball type. The easternmost section (0·6 mile) of the aqueduct is a 48-in. diameter concrete conduit working under a few feet of water pressure.

The machinery of the Cults steam pumping-station was scrapped, and electrically-driven centrifugal pumps were installed in duplicate.

A circular covered service-reservoir, of a capacity of 7 million gallons, was constructed. The walls are of plain concrete with expansion joints. The roof is of the ordinary reinforced-concrete beam-and-slab construction, covered with asphalt, and is supported by plain concrete piers. The outlet-pipe is 30 in. in diameter. It is coupled to a 24-in. main, 3½ miles long, which formerly fed the Cattofield low service-reservoir (2·5 million gallons), and this main thus becomes the leading main of a new distribution zone. The Cattofield reservoir will be used in the future principally as a booster reservoir for the low service zone, whilst also serving a small district of its own.

The cost of the works carried out exceeded 900,000*l.*

* Abstract of a paper read before the Institution of Civil Engineers on Tuesday, April 7, 1925.

ONE-TON ELECTRIC PULLEY BLOCK.

WE illustrate on pages 448 and 449 of this issue, a 1-ton electric pulley block, in which the makers—Messrs. S. H. Heywood and Co., Limited, Reddish, near Stockport—have aimed at embodying the results of their exceptionally long experience with all varieties of lifting gear. The handiness of the electric pulley block, in the past, has often been largely discounted by two defects, viz., a liability to get out of order and a difficulty in effecting repairs owing to the lack of accessibility of the various components. The block which forms the subject of our illustrations, the makers claim, is not merely "fool-proof," to use an expressive Americanism, but very special attention has been paid to the easy and rapid dismounting and reassembly of the constituent parts.

As stated, the block is of 1-ton capacity, and it will lift this load at a maximum speed of 20 ft. per minute.

ONE-TON ELECTRIC PULLEY BLOCK.

CONSTRUCTED BY MESSRS. S. H. HEYWOOD AND CO., LIMITED, ENGINEERS, REDDISH, NEAR STOCKPORT.

Fig. 1.

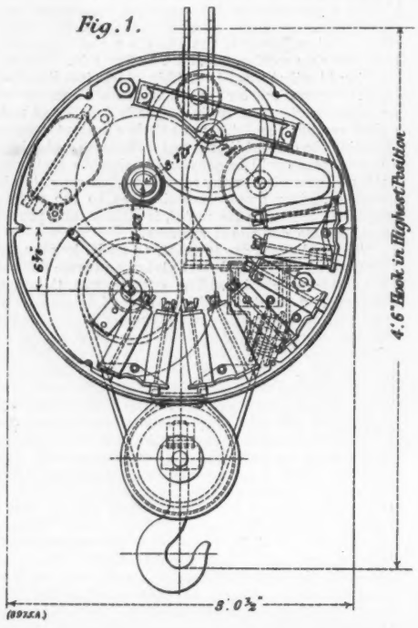


Fig. 2.

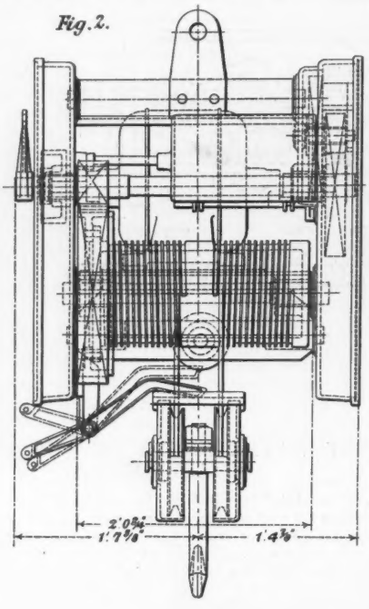
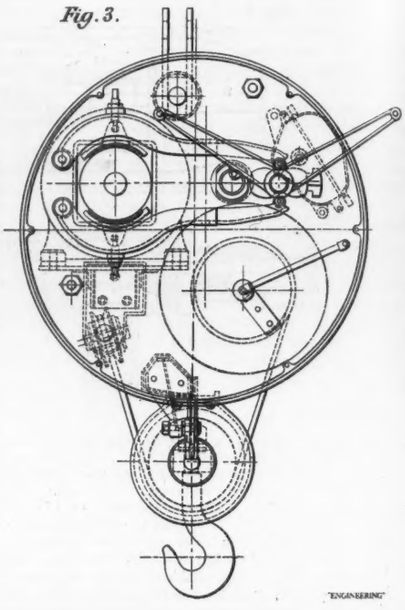


Fig. 3.



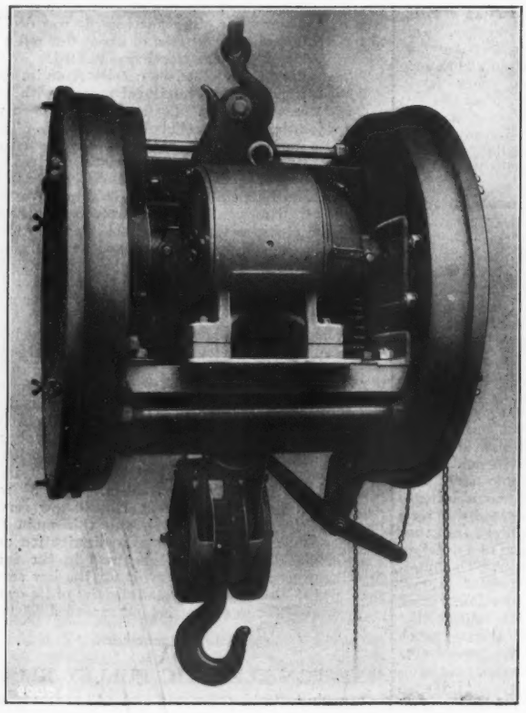


FIG. 4.

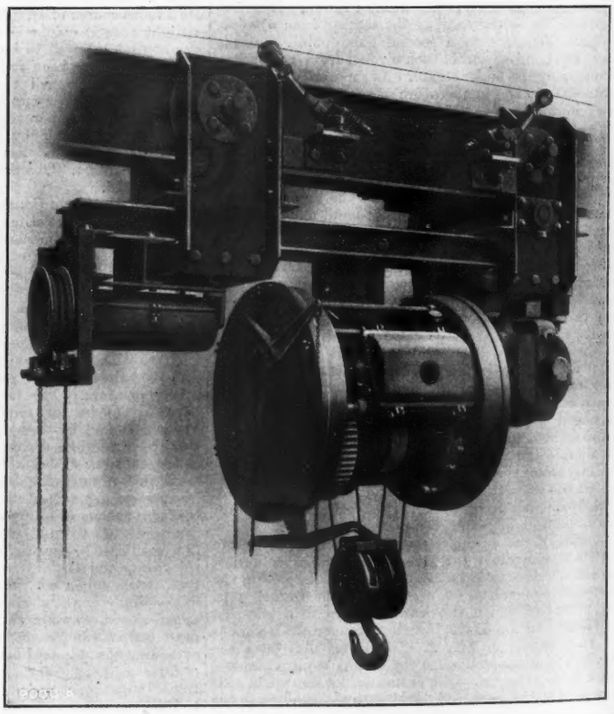


FIG. 5.

The load is held automatically in all positions; if the control levers are released, and no matter how sudden this release may be, the barrel of the controller is always brought to rest in the neutral position, and can never overshoot this and reverse the motor, as may happen with many of the electric pulley blocks hitherto in use. Moreover, should the current fail whilst a load is being lifted or lowered, no runaway can occur, even though the operator may continue to hold the automatic brake out of action. Under the conditions stated, the load drives the motor as a generator, and the electric braking action thus provided is sufficient to keep the speed of the falling load within very moderate limits. A quick make and break is provided for every step of the controller. Every contact is either fully on or completely broken, so that arcing is impossible. The resistance coils are mounted in a casing separate from the controller, and are very amply proportioned, being capable of taking the full current for a period of five minutes, although it has hitherto been usual in electric-crane practice to design these resistances to carry the full current for only 30 seconds, so far as the first notch is concerned, and for an additional 90 seconds distributed over the remaining notches. Four lowering speeds are available and on none of these speeds is there any acceleration after the controller has been moved on to the corresponding notch, each speed being self governing.

The general character of the block is well represented in Figs. 1, 2 and 3, above, but is, perhaps, even more clearly displayed in Figs. 4 to 9, which have been reproduced from photographs. In Fig. 4, the motor is shown in position, whilst the opposite side is shown in Fig. 5, this view being of a block mounted as an electric travelling unit.

The framework of the block is represented separately in Fig. 6. It consists of two steel castings in the form of shallow circular dishes, which are connected together by the bolts and cross pieces shown. The fixed shaft,

ONE-TON ELECTRIC PULLEY BLOCK.

CONSTRUCTED BY MESSRS. S. H. HEYWOOD AND CO., LIMITED, ENGINEERS, REDDISH, NEAR STOCKPORT.

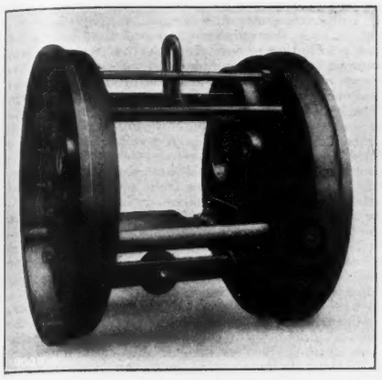


Fig. 6.

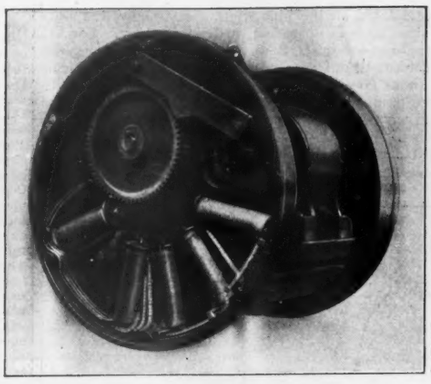


Fig. 7.

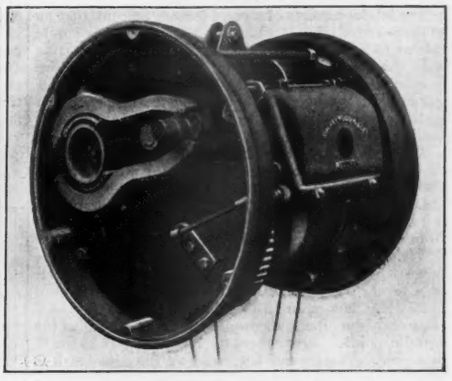


Fig. 8.

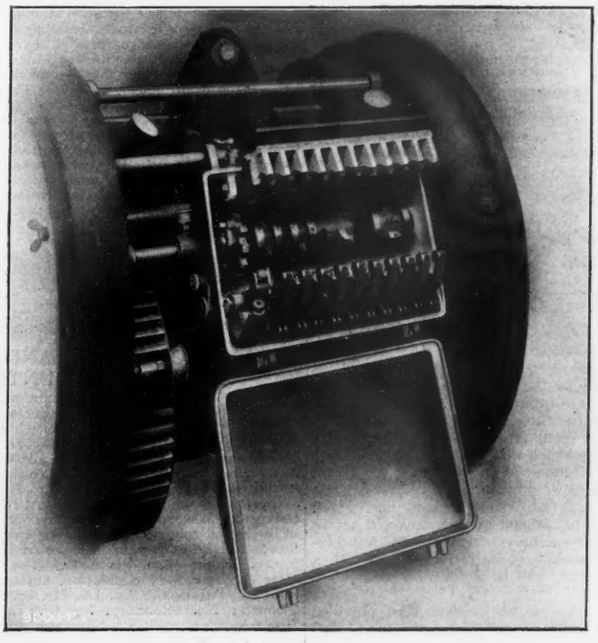


Fig. 9.

on which the rope barrel rotates, can be seen at the front, and behind it is the platform on which the motor is mounted. This motor is a standard pattern, and is secured in place simply by the holding-down bolts shown in Fig. 4. One end of the motor-shaft is fitted with a pinion, which passes through the large hole visible in the right-hand end casting, Fig. 6, and this gears with one of the wheels of the reduction gear, as clearly indicated in Fig. 7. The other end of the shaft is keyed to take the brake pulley, represented in Fig. 8. This is securely held in position by a sunk key and by the set screws shown, but it can be removed in less than 30 seconds if the need arises. On removing this pulley, the motor is free to be withdrawn by unbolting it from its platform.

It will be seen from Figs. 7 and 8 that the resistance coils belonging to the controller, and most of the gearing, are accommodated within the one end plate of the framing, and the brake pulley, with its levers, springs, and other accessories, in the other end casting. In service, the whole of these working parts are protected by end covers of steel plate, which are held in position by thumb-screws, as is, perhaps, best seen in Figs. 4 and 5.

The brake levers are held in the on position by the stiff springs shown. On pulling down either of the control levers (see Fig. 5) the cam-plate shown between the ends of the brake levers in Fig. 8 is rotated, forcing the levers apart and releasing the brake pulley. Simultaneously, the barrel of the controller is rotated either through one or more notches or immediately to the "full on" position. This controller barrel is coupled to the cam-plate shaft through the gears just visible in Fig. 8. Should the control lever be suddenly released, either by accident or design, the rollers, at the end of the brake arms force round the cam-plate to the neutral position and hold it there. The barrel of the controller follows this movement. The whole of the shock consequent on such a sudden release, it will be seen, is taken up on the very robust parts of the brake arms and the cam plate, and is not transmitted to the controller barrel.

A view of the controller opened out for inspection is given in Fig. 9. It will be seen that the brushes are mounted on a hinged frame, which can be swung back in the manner shown. The partition plates of asbestos board, which in the working position come between and isolate the brushes from each other, are similarly mounted at the top of the casing, and when both brushes and contacts are swung into the positions shown the barrel of the controller is immediately accessible. Moreover, it is mounted in such a fashion that it can be removed entirely in somewhat less than 10 seconds.

The brushes are of copper and are spring-mounted. As already stated, each contact is provided with a quick make and break, ensuring that it is either fully on or fully off.

The usual automatic throw-out is fitted to prevent over-winding. This can be seen in Fig. 5. If the attempt be made to overwind, the hook fouls the lever shown, which is coupled by a chain to the control lever, and hence the latter is pulled over, cutting off the current.

One small point which may be mentioned is that none of the main components of the block projects beyond the rims of the end castings. The block can therefore be rolled along the ground, which may often be a convenience in shifting it from one position to another.

The special features of the block are covered by patents, and it is made in a number of sizes for loads ranging from 10 cwts. to 4 tons.

BRISTOL WATERWORKS: CHEDDAR SUPPLY.*

By Alexander McCulloch Paterson, M.C., M.Inst.C.E.

The present Bristol Waterworks Company was incorporated in 1846. Before that date, the city was supplied by numerous springs and wells. Since then, but previous to the Cheddar scheme, works have been undertaken from time to time, which give a daily average supply of 12¼ million gallons to a population of 400,000. In 1914 it was decided to obtain water from Cheddar, at the foot of the Mendip Hills, 19 miles south-west of Bristol. This scheme (see map, page 450) provides for drawing water from the stream at Cheddar, which is formed by numerous springs breaking out of the limestone at the foot of the gorge, its gravitation to a pumping station one mile below the intake, and pumping from there into Yeo reservoir, 9½ miles distant. The Cheddar supply is at present a standby, to be made use of from time to time as required. The present capacity of the pumping station is six million gallons *per diem*, with three equal units in operation. When consumption increases so as to justify an extension, it is proposed to duplicate the pumping plant, with a maximum operating capacity of 10 million gallons *per diem*, one unit standing idle.

Gaugings of the flow of the stream have been taken daily since the end of 1915. These record a fluctuation in flow from 2·2 million gallons *per diem* on November 1, 1921, to 83 million gallons on January 7, 1919. The average daily flow, from 1916 to 1922 inclusive, but omitting 1921, is 17·9 million gallons, with an average annual minimum of 4·9 million and maximum of 69·9 million gallons.

No storage is provided at Cheddar; therefore, with pumps each of a minimum capacity of two million gallons *per diem*, the minimum stream-flow upon which a pumping unit can feasibly operate is five million gallons *per diem*, three million gallons being required for compensation water. Working on this figure as the minimum, in an average year a daily average of five million gallons can be pumped. It is ultimately intended to provide a storage reservoir of two million gallons capacity close to the pumping station. When the installation is increased to its ultimate intended maximum working capacity of 10 million gallons *per diem*, the daily average expectation for an average year would be raised to 7·3 million gallons without storage, and to 7·9 million gallons with storage.

The various works comprised by the undertaking

* Abstract of a paper read before the Institution of Civil Engineers on Tuesday, April 7, 1925.

are: (1) the intake on the stream at Cheddar; (2) a gravitation main from the intake to the pumping station; (3) the pumping station; (4) the pumping main to the Yeo reservoir, 9½ miles in length; (5) a service reservoir at the summit point at Rowberrow; and (6) drainage and other protection works at Cheddar.

The intake consists of a pond formed by constructing a dam across the stream, with a covered concrete intake tank having six arched inlets communicating with the pond. The water to be passed down-stream is admitted to a gauge chamber by a circular-orifice gauge built through the dam, of such a diameter that water cannot pass into the intake tank until three million gallons *per diem* is passing through the gauge.

The gravitation main is 1,900 yards in length, of 33-in. cast-iron pipes, and conveys the water through Cheddar, from the intake-tank (water-level 65·4 ft. O.D.) to the pump-inlets (51·0 ft. O.D.). The pumping main is 9½ miles in length. It conveys the water from the pump level of 53 ft. O.D. over a summit of 305 ft. O.D. at Rowberrow, 5 miles distant, and thence down to Blagdon, discharging into the Yeo reservoir at a level of 148 ft. O.D. The maximum static head is 296 ft. The main is 33 in. in diameter—of B or C class cast-iron pipe, according to the level—as far as the 7½-mile point. From there to Blagdon it is 24 in. in diameter. The ground traversed by the pipe-track is generally red marl overlying the dolomitic conglomerate. For 1½ miles, the trench was cut through this rock. The summit hill at Rowberrow is of carboniferous limestone, through which a tunnel was driven. In the low-lying ground near Axbridge peat was encountered for 400 yards, and in one place the pipes were carried on concrete piers for 200 yards.

The chief interest of the pipe-laying was the comprehensive employment of mechanical plant for the work. This comprised a steam excavator, pneumatic hammers for setting up the joints, a petrol-driven backfiller, and a petrol locomotive on a 2-ft. railway for distributing the pipes. Records of the cost of pipe-laying are given in an Appendix to the paper.

The steam excavator was used throughout, excepting in lengths where rock was met. Under best conditions, it cut 440 yards of 33-in. pipe trench in a 49-hour week. Its normal rate of travel was 6 or 7 yards per hour. The average total cost of excavation was approximately 3*s.* 3*d.* per cubic yard, with labour at 1*s.* 7*d.* per hour, and plant bought when prices were a maximum. The cost of hand excavation would have been 5*s.*

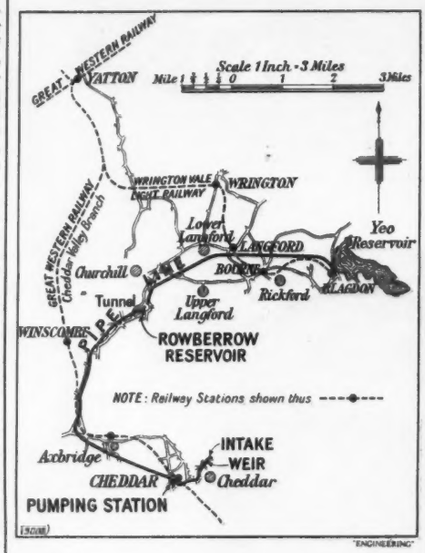
Over 75 per cent. of the pipe-joints were set up by pneumatic caulkers operated by a petrol-driven air compressor. The joints of the whole of the high-pressure sections of the pipe-line were caulked in this way, and the results are considered satisfactory. The joints are of lead (2¾ in. deep in the 33-in. pipes) poured against the usual backing of yarn. The jointers worked in pairs, and under good conditions two men would set up a joint in 15 minutes.

The backfiller is a petrol-driven machine which drags the material into the trench by means of a scoop working on a drag line. The cost of refilling the 33-in. pipe trench by its means was 4*s.* to 4*s.* 6*d.* per lineal yard, which represents little, if any, saving over hand labour.

Rowberrow tunnel is situated at the summit of the pipe line, a little over 5 miles from the pumping station. It is 224 yards long, 10 ft. 6 in. wide, and 8 ft. high, with a maximum depth below ground of 75 ft. The pipe is carried on piers on one side of the tunnel, whilst on the other is laid a 2-ft. gauge railway. The driving of the tunnel took nearly nine months, and was worked from one face. Both day and night shifts, of eight men each, were worked for the second half of the period, the weekly progress being 25 ft. to 30 ft. Machine drilling was employed throughout. The charges were fired by electricity. The average cost of excavation per cubic yard was 50*s.* A length of 65 yards was lined with 1 : 3 : 6 concrete, 18 in. thick, which saved 25 per cent. of the cost of brickwork.

The pumping station is situated close to Cheddar station and alongside the Great Western Railway, a siding from which enters the grounds. The buildings, of red brick, comprise the engine house and four out-buildings, namely, the board room, workshop block, boiler-house and oil store, and a small combined coal store and tool-house. The pumping plant consists of three independent sets of high-speed centrifugal pumps driven, through the intermediary of toothed helical gearing, by solid-injection crude-oil engines. Under the contract each unit is capable of pumping 2 million gallons *per diem* (1,400 gallons per minute) against a total head of 306 ft. The engines are of the Ruston-Hornsby two-cylinder horizontal type, built for a working load of 234 brake horse-power. The pumps are Mather-Platt 8-in. split-casing, five-stage centrifugals, designed to run at a speed of 1,000 r.p.m.

The official pumping trials took place in January, 1923, and were conducted by Captain H. Riall Sankey. The conditions under which the plant will operate initially are materially different from those which will ultimately obtain. The specified head of 306 ft. allows for pumping from the future storage-reservoir at the pumping-station, as against the present working under the head from the intake, and is calculated on the pipe friction caused by five units in simultaneous operation, instead of three. For the purpose of the trials, it was necessary to run the plant under conditions approximating as closely as possible to those specified. The present working head with three pumps running is about 261 ft., and an artificial head was therefore imposed by throttling the delivery valves. With the head increased in this manner to 303 ft., a pump discharge of 1,680 gallons per minute was obtained. The oil consumption per brake horse-power hour under these conditions was 0·44 lb., or 0·62 lb. per horse-power delivered to the main, with a brake horse-power of 220.



Tests were made by the author at a reduced speed, the delivery valves being fully open. With the three units running together the oil consumption was 0·42 lb. per brake horse-power-hour, or 0·59 per pump horse-power hour, at an average of 170 brake horse-power per unit and a pump efficiency of 73 per cent.

Rowberrow reservoir is built close to the summit of the pipe-line and the eastern end of the tunnel. It has a capacity of 500,000 gallons, and will act as a service reservoir for supplying water to the Axbridge Rural District Council. It is 90 ft. square, with a water depth of 10 ft., and is of concrete with brick-faced walls.

Drainage and sewerage works have been provided at Cheddar. Property at and above the intake has been bought to keep control of the stream, and the latter is covered in for 80 yards above the intake pond. To operate the compressed-air ejectors on the drainage system, a small water-turbine plant supplied by an automatic radial sluice was installed on the stream.

BOOKS RECEIVED.

Reinforced Concrete Bridges. The Practical Design of Modern Reinforced Concrete Bridges, including Notes on Temperature and Shrinkage Effects. By W. L. SCOTT, assisted by C. W. J. SPICER. London: Crosby Lockwood and Son. [Price 42*s.* net.]

Screw Propellers and Estimation of Power for Propulsion of Ships, also Airship Propellers. Vol. I, *Text.* Vol. II, *Atlas.* By Rear-Admiral CHARLES W. DYSON, U.S.N. Third edition re-written. New York and London: Simmons-Boardman Publishing Company. [Price 3*l.* 7*s.* 6*d.*]

United States Bureau of Standards. Scientific Paper No. 495. *A Radiometric Investigation of the Germicidal Action of Ultra-Violet Radiation.* By W. W. COBLENTZ and H. R. FULTON. [Price 20 cents.] No. 496, *Effect of Stress on the Magnetic Properties of Steel Wire.* By R. L. SANFORD. [Price 5 cents.] No. 498, *Tables for the Calculation of the Mutual Induction of Circuits with Circular Symmetry about a Common Axis.* By F. W. GROVER. [Price 10 cents.] Washington: Government Printing Office.

La Relativité Dégagée d'Hypothèses Métaphysiques. By H. VARCOLLIER. Paris: Gauthier-Villars et Cie. [Price 50 francs.]

Shirley Institute Memoirs. Vol. III, 1924. Didsbury, Manchester: Shirley Institute.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The approach of the Easter holidays finds the local iron and steel trades occupying a very patchy and, for the most part, unsatisfactory condition. There is practically no movement of any volume in basic iron and steel, nor has there been for several weeks past. Output has therefore shrunk, and it is not surprising to hear the opinion expressed that, unless the general position improves after the holiday set-down, the amount of plant re-commissioned will be even smaller. Headway in crude steel seems out of the question in face of the increased force of foreign underselling. Finished iron is in a very similar position, local products being substantially undersold by imported material. There is some buying of scrap, but it is mainly for export to American and other overseas furnaces. The current level of prices is the lowest recorded this year. Competition is also spreading from semi-manufactured materials to engine and machinery parts. It is no longer a secret that the bulk of engineering firms, as well as steelmaking and steel manipulating concerns, have taken large numbers of contracts at bare cost (and in some cases actually below cost) with the idea of keeping together the nucleus of expert staffs and keeping machinery running. Even where, in exceptional cases, plants have operated for a period at something approaching full capacity, the net result has been to increase the companies' indebtedness. The difficulty of maintaining plant in an up-to-date condition in face of circumstances such as these becomes more acute and, according to leading manufacturers, calls for special relief in the form of reduced taxation.

South Yorkshire Coal Trade.—The position has undergone no substantial alteration during the past week. Output is maintained round about its former level, but with exports continually shrinking, this involves the throwing on the home markets of heavy surpluses, and an increased competition for the orders in circulation. Collieries are hampered in meeting the demand for cheap fuel for industrial purposes by the unrelieved burden of production and transport costs. Best hards are moderately active on inland account. Business in best quality slacks keeps at a fair level, but prospects are damped by the condition of the cotton trade. Cobbles and nuts have developed fresh weakness. The house coal trade, on the whole, is quiet, with secondary grades in abundant supply. Quotations:—Best branch hand-picked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire Brights, 28*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 20*s.* to 24*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; smalls, 4*s.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business is on a limited scale, but Cleveland pig-iron is somewhat scarce, makers being fairly well sold, and carrying very small stocks. Under such favourable statistical conditions, little improvement in demand is needed to stiffen the market. At present, however, customers are acting cautiously, and prices are barely maintained. At the same time, the feeling is rather pronounced that quotations are not likely to fall appreciably, and hope is entertained that orders will be released with more freedom in the near future. Home demand is moderate, and there is rather more export inquiry circulating, but overseas sales are not easily arranged. No. 1 is 82*s.* 6*d.*; No. 3, g.m.b., 77*s.* 6*d.*; No. 4 foundry, 76*s.* 6*d.*; and No. 4 forge, 75*s.* 6*d.*

Hematite.—Unsatisfactory accounts are given of the East Coast hematite branch. Makers are hampered by considerable unsold accumulations at their works, and both home and export demand falls vastly below what could be desired. Quotations are irregular and weak. Sellers put Nos. 1, 2 and 3 at 83*s.* but below that figure has been accepted. No. 1 is quoted sixpence above mixed Nos.

Manufactured Iron and Steel.—Most descriptions of manufactured iron and steel are difficult to dispose of, and are weak in price, an outstanding exception being galvanised sheets demand for which is heavy and values of which tend upward. Common iron bars are 12*l.*, iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel ship, bridge and tank plates, 8*l.* 17*s.* 6*d.*; steel angles, 8*l.* 12*s.* 6*d.* steel joists, 8*l.* 12*s.* 6*d.*; heavy steel rails, 9*l.*; and galvanised corrugated steels (24 in. gauge, in bundles), 16*l.* 15*s.*

Iron and Steel Shipments.—Iron and steel shipments from the Tees during March were the heaviest of any month so far this year, totalling 98,001 tons, of which 35,915 tons were pig-iron, 12,813 tons manufactured iron, and 49,273 tons steel. Of the pig-iron cleared, 10,611 tons went to foreign ports, and 15,304 tons went coastwise; of the manufactured iron despatched, 6,876 tons went abroad, and 5,937 tons went coastwise; and of the steel loaded 36,045 tons went overseas, and 13,228 tons went coastwise. Scotland was the heaviest receiver of pig-iron, taking 12,807 tons, whilst Italy imported 5,125 tons; Germany, 2,768 tons; and the United States 2,645 tons. The Cape of Good Hope, with an import of 5,618 tons, was the largest customer for manufactured iron. India was again the heaviest buyer of steel, receiving 11,564 tons; and other principal customers

for steel were: Kenya, 4,711 tons; Australia, 4,176 tons; the Netherlands, 4,133 tons; and the Argentine Republic 2,143 tons.

Imports of Iron and Steel.—Tees Conservancy Commission statistics, issued this week, show imports of iron and steel to the Tees from Holland, Belgium, France, Norway, Sweden, Germany, India and coastwise for the five months ended March 31 last compared with the same months a year ago, and with the corresponding pre-war period of 1913–14. Pig-iron arrivals in the past five months totalled 6,497 tons, as against 7,730 tons for the same time a year ago, and 54 tons for the pre-war period; crude sheet bars, billets, blooms and slabs unloaded in the past five months reached 58,596 tons, as against 27,096 tons a year ago, and 19,970 tons in the pre-war period; and plates, bars, angles, rails, sheets, and joists imported in the past five months amounted to 10,113 tons, as against 6,520 tons a year ago, and 11,242 tons in the pre-war period.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No change of any note falls to be recorded in connection with the steel trade of Scotland during the past week. Makers continue to complain of the scarcity of specifications against contracts, and also of the paucity of inquiries. In few cases can a full week's work be obtained to keep the mills in operation going steadily, and the day-to-day demand is not satisfactory. The marking down of the official quotations has not had much effect on business, and conditions are very much as they were. The black-sheet trade is practically unchanged, and a fair amount of business is going through, with galvanised sheets finding a ready outlet. The following are the market quotations:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 10*s.* per ton; sections, 9*l.* 5*s.* per ton; and sheets, $\frac{7}{16}$ to $\frac{1}{2}$ in., 11*l.* per ton—all delivered Glasgow stations.

Malleable-Iron Trade.—A lifeless state still prevails in the West of Scotland malleable-iron trade, and producers are receiving little encouragement from the current demand. The steel re-rolling mills continue well employed and are turning out quite a good tonnage. The export demand for bar-iron is infinitesimal. Prices are unchanged with "Crown" bars called at 12*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade there is a great lack of demand, and movement all round is of the most meagre description. Inquiries are poor, and with sales on such a small scale stocks continue to increase. Prices have an easier tendency, and the following may be taken as the current quotations: Hematite, 4*l.* 11*s.* 6*d.* per ton delivered at the steel works; foundry iron, No. 1, 4*l.* 10*s.* 6*d.* per ton; and No. 3, 4*l.* 8*s.* per ton; both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, April 4, amounted to 590 tons. Of that total, 463 tons went to foreign destinations and 127 tons went coastwise. For the corresponding week of last year the figures were 878 tons overseas and 479 tons coastwise, making a total shipment of 1,357 tons.

Railway Material Contract.—In the large expenditure of about 14,000,000*l.* on new rolling-stock, on the part of the London, Midland & Scottish Railway, Glasgow district will benefit to a considerable extent. Orders for many railway wagons and carriages have already been placed locally, and the latest announcement is that about 100 new locomotives are to be built in Glasgow. This contract will be shared by the company's own works at St. Rollox and other locomotive builders in the City. In order to deal more rapidly with the work at St. Rollox, the company has just placed a good contract with Messrs. Sir William Arrol and Co. (Limited), to instal powerful overhead cranes, electrically driven. These cranes, which will each have a lifting capacity of 50 tons, will handle with ease the heaviest type of present-day engine, and their use will help materially to reduce the time spent on repair jobs.

INSTITUTION OF NAVAL ARCHITECTS—CORRECTION.—We regret that, through a printer's error in our report of the proceedings at the meeting of the Institution of Naval Architects, on Wednesday, April 1 (see page 424 of our last issue), we made it appear that Mr. H. Ruck-Keene thought that the adjustments required by Diesel engines were "fewer" than was the case with steam machinery. The word should have been "finer."

CONTRACTS.—Messrt. Edgar Allen and Co., Limited, of Imperial Steel Works, Sheffield, have secured, among other contracts, one for a complete cement manufacturing plant, including electric motor equipment, for the Dunstable Portland Cement Company, Limited, of Dunstable, Bedfordshire. This plant will have a capacity of 110,000 tons per annum. A further order has been received for a dry-process cement manufacturing outfit having a capacity of 100,000 tons per annum for the Standard Portland Cement Company, Limited, of New South Wales, Australia.—Messrs. H. R. Marsden, Limited, of Soho Foundry, Meadow-road, Leeds, have secured orders from the Inverness Town Council for stone-breaking, elevating, screening and tar-macadam plant; from Gordon Quarries, Limited, Hawick, for crushing, elevating and screening apparatus; and from the Devon County Council (Southern Division), Newton Abbot for granulating and screening equipment.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Docks Traffic.—The depressed state of trade in South Wales is clearly shown in the returns issued by the Great Western Railway Company of the seaborne traffic of the six docks controlled by them in the three months ended March 22. It is shown that, in this period, 8,441,086 tons of goods were exported and imported at the Cardiff, Penarth, Barry, Newport, Swansea and Port Talbot docks, which was 1,097,904 tons less than that dealt with in the corresponding period of 1924, representing a reduction at the rate of 4,700,000 tons per annum. Exports alone, at 7,157,331 tons, accounted for a reduction of 1,023,238 tons, of which the coal and coke trade, with 6,414,939 tons, was responsible for a decrease of 1,062,832 tons. Shipments of iron and steel fell by 11,136 tons to 77,080 tons, tinplates by 6,321 tons to 140,918 tons, grain and flour by 31,447 tons to 28,618 tons, and pitwood and mining timber by 3,200 tons to 308,583 tons. On the other hand, exports of patent fuel were increased by 20,947 tons to 231,815 tons and of oil by 34,687 tons to 223,293 tons. The import trade too showed a reduction of 74,666 tons to 1,283,755 tons, arrivals of all commodities decreasing with the exception of oil and iron and steel. The trade of the docks in the twelve weeks ended March 22, is shown below:—

Four weeks ended:—	Imports Tons.	Exports Tons.	Total Tons.
Jan. 25 ...	424,408	2,357,200	2,781,608
Feb. 22 ...	426,150	2,591,407	3,017,557
Mar. 22 ...	487,259	2,384,426	2,871,685

Welsh Miners and Wages Agreement.—The South Wales miners met at Cardiff on Saturday to consider the policy to be pursued in connection with the revision of the existing general wages agreement. Proposals of a far-reaching character were adopted; but this is usually the case. These included a demand for a minimum wage equivalent to the 1914 earnings plus a wage to cover the increased cost of living as disclosed by the Board of Trade figures, and the re-institution of the Sankey wage of 2*s.* per day. It was also decided to ask for a guaranteed weekly wage with two weeks holiday with pay every year, also that membership of the Miners' Federation should be a condition of employment at the collieries.

Trade Organisations.—Mr. C. L. Clay and Mr. John Powell have been re-elected chairman and vice-chairman, respectively, of the South Wales Coal Exporters' Federation and Mr. D. Rupert Phillips and Mr. Percy I. Scott have been re-elected chairman and vice-chairman, respectively, of the Cardiff and Bristol Channel Pitwood Importers' Association.

THE ROYAL AERONAUTICAL SOCIETY.—The 60th annual general meeting of the Royal Aeronautical Society was held in the Society's offices, at 7, Albemarle-street, London, W.1, on the 31st ultimo. In moving the adoption of the report and accounts, which showed a deficit for the year, the chairman, Lieut.-Col. H. T. Tizard, referred to the fact that since the war the Society had been passing through difficult times, which had culminated in the resignation of the Secretary, Lieut.-Col. W. Lockwood Marsh. The Council felt that the loss of a permanent secretary was a serious matter, but, in view of the financial position, it would be necessary to make do with the services of an honorary secretary for the time being. An endowment fund of some 10,000*l.* was really needed to put the Society into a stable position. He also mentioned that negotiations had been going on for some time with a view to the amalgamation with the Society of the Institution of Aeronautical Engineers, and expressed the hope that a satisfactory arrangement would be come to. The report was duly adopted, as also was a resolution recording the Society's indebtedness to the retiring secretary for his conduct of the business during five exceptionally difficult years.

THE LATE MR. ARTHUR JACOB.—We regret to announce the death of Mr. Arthur Jacob, which occurred on April 3, at Merrow, Hatch End, Middlesex. Born 57 years ago, he was the second son of Dr. Hamilton Jacob, Dublin, and for some time subsequent to 1884 was associated with Dr. S. Z. de Ferranti at Grosvenor Gallery and Deptford. This period was followed by a lengthy experience in the construction and management of electrical engineering undertakings throughout the country. As Resident Engineer for the British Thomson-Houston Company in the complete electrification of the Dublin United Tramways Company's system, he supervised the erection of power stations and the electrical equipment of over 42 miles of track and 300 cars. Later, Mr. Jacob took part in the management of the British Schuckert Electric Company, Limited, London, which organisation was later taken over by Siemens-Schuckertwerke, of Berlin. The deceased gentleman afterwards took up an appointment on the managerial staff of the central-station department of Messrs. Siemens Brothers Dynamo Works, the latter situated at London and Stafford. In the year 1908, Mr. Jacob undertook the management of the British Aluminium Company, Limited, which position he held until his death. During the intervening years, he was responsible for much of the development of the use of aluminium for industrial purposes in general and electrical purposes in particular. Mr. Jacob was a member of the Institution of Electrical Engineers, the Institute of Metals, the Executive Committee of the British Engineers' Association, and of the Federation of British Industries. Further, his membership of the American Institute of Electrical Engineers and of the American Electrochemical Society testifies to his energy and wide interests.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—Thursday, April 16, at 4.30 p.m., at John-street, Adelphi, W.C.2. Dominions and Colonies and Indian Sections. Joint Meeting. "The British Empire Exhibition," by the Rt. Hon. Lord Stevenson, G.C.M.G.

THE INSTITUTION OF MECHANICAL ENGINEERS: MIDLAND BRANCH.—Thursday, April 16, at 6 p.m., at the Queen's Hotel, Birmingham. "The Scientific Treatment of Boiler Feed-Water, introducing the Colloidal Aspect," by Mr. W. B. Lewis and Mr. G. S. Irving, F.C.S.

THE OPTICAL SOCIETY.—Thursday, April 16, at 7.30 p.m., at the Imperial College of Science and Technology, Imperial Institute Road, South Kensington, S.W.7. "The Geometrical Solution of Colour-Mixture Problems," by Mr. J. Guild, A.R.C.Sc. Messrs. Peeling and Van Neck will exhibit and describe: The Hahn-Goerz Workshop Microscope and The "Artisol" Mirror Arc Lamp.

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, April 16, at 7.30 p.m., at the Institute of Marine Engineers, 85/88, The Minories, Tower-hill, E.1. "Metals in the Gaseous State," by Mr. C. H. M. Jenkins.

THE DIESEL ENGINE USERS' ASSOCIATION.—Friday, April 17, at the Engineer's Club, Coventry-street, W.1. "Recent Oil-Engine Developments," by Mr. J. L. Chaloner.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 17, at 7.30 p.m., at 39, Victoria-street, S.W.1. Ordinary Meeting. "Vertical Retorts," by Mr. Walter T. Dunn, M.I.Mech.E.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, April 18, at 3 p.m., at the Royal Technical College, Glasgow. Annual General Meeting. Prof. Henry Brigg on Sinclair's Treatise of Coal Mining, 1672 ("Seventeenth Century Mining in East Lothian"). "The Principles and Operation of the Mines (Working Facilities and Support) Act, 1923, Part 1," by Mr. J. H. Cockburn. A Demonstration will be given by Mr. C. Norman Kemp, B.Sc., and Mr. William M'Laren, B.Sc., on "Coal Washing."

AUTOMATIC TUBE-TRAIN INDICATORS.—The Underground Company have announced that a complete system of station and signal-cabin automatic train indicators is about to be installed on the Hampstead and City group of railways. The system of indicators will be similar to that used on the District Railway for some years past, but of an improved pattern.

ROYAL AIR FORCE CADETSHIPS.—The Air Ministry announces that a competitive examination for not less than 35 cadetships at the Royal Air Force Cadet College, Cranwell, Lincs., will commence on June 23 next. The written examination will be held in London and certain other centres in the United Kingdom. Applications should be made to the Secretary, Civil Service Commission, Burlington-gardens, London, W.1, and no entry form will be accepted after April 23. The age limits for candidates are now 17½ and 19½ years.

TENDERS.—The Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, announces that the Egyptian Ministry of Finance invites tenders for the supply of photographic paper and chemicals. Offers should be presented in Giza by noon on June 10, 1925.—The Finnish Water Power Department invites tenders for two electrically-operated overhead travelling cranes, each having a lifting capacity of 75 tons. Offers must be valid until September 1, and be presented in Finland by June 1, 1925. All inquiries regarding these tenders should be addressed to the Department.

PADDLE STEAMER "CRESTED EAGLE."—Messrs. J. Samuel White and Co., Limited, of East Cowes, launched on March 26, the steel paddle passenger steamer Crested Eagle, which is being built to the order of the General Steam Navigation Company, Limited, for service between London and Ramsgate. The vessel was designed by the builders from plans supplied by the owners' naval architect, Mr. William Gray, of 18, Billiter-street, London, and has the following dimensions:—Length overall, 309 ft. 3 in.; extreme and moulded breadths, 68 ft. 10 in. and 34 ft. 6 in., respectively; and moulded depth to main deck, 11 ft. 6 in. The speed is estimated to be 18½ knots. Intended to carry up to 1,650 passengers, the ship is being built of steel to the requirements of class A at Lloyds and in conformity with the Board of Trade Regulations necessary for obtaining the Nos. 3 and 4 Steam Certificates for this service. The main deck runs continuously from the straight stem to the elliptical stern and the promenade deck from the stem to within 14 ft. of the stern post. The hull is divided by watertight bulkheads into 10 compartments. A telescopic funnel and hinged mast are fitted to permit the vessel to pass under London Bridge, while a bow rudder will facilitate steering. Oil-fuel bunkers are built in the main structure ahead of the boiler-room bulkhead. Provision has been made for the fitting of coal bunkers at the side of the boiler-room, which latter contains two single-ended, return-tube units working at a pressure of 180 lb. per sq. in., fired by oil-fuel on the low-pressure system, and operating under forced draught. The propelling machinery, constructed by the builders, consists of a set of surface-condensing, triple-expansion, diagonal paddle engines, having cylinders 30 in., 46 in. and 69½ in. in diameter, with a 66 in. stroke. Electric power for lighting, &c., will be supplied by three generators, two being steam-driven and one oil-driven, while the auxiliaries will be mainly steam-driven. The vessel is is expected to be commissioned for service this summer.

DRY DOCK AT CONGELLA, DURBAN, SOUTH AFRICA.

(*For Description, see Page* 438.)

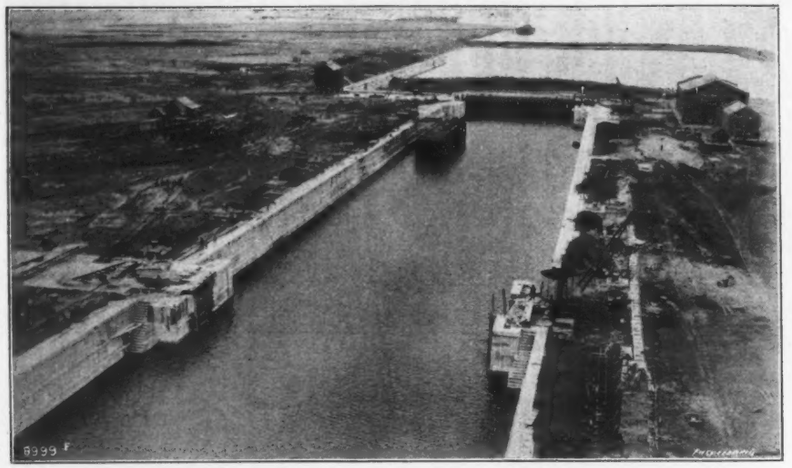


Fig. 32. The Dock Chamber; Entrance Closed by Outer Caisson.

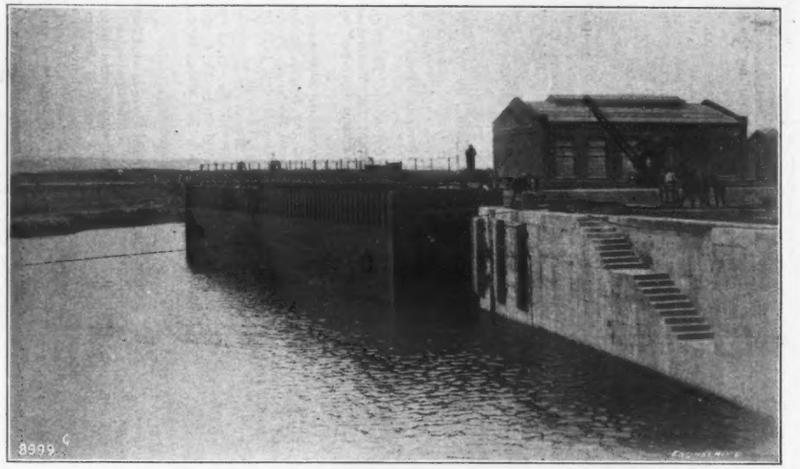


Fig. 33. Outer Caisson being Floated on to Emergency Seating at Entrance.

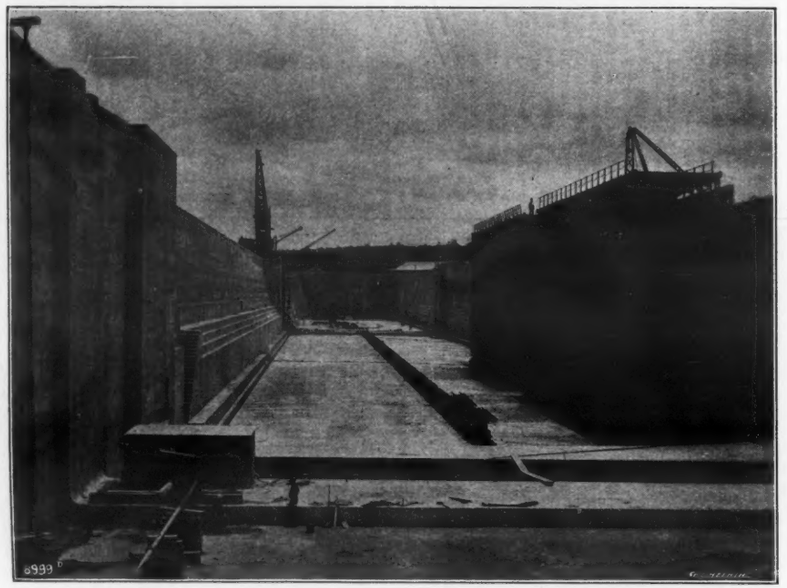


Fig. 34. Dock Chamber; View showing Seatings and Roller Path for Outer Caisson.

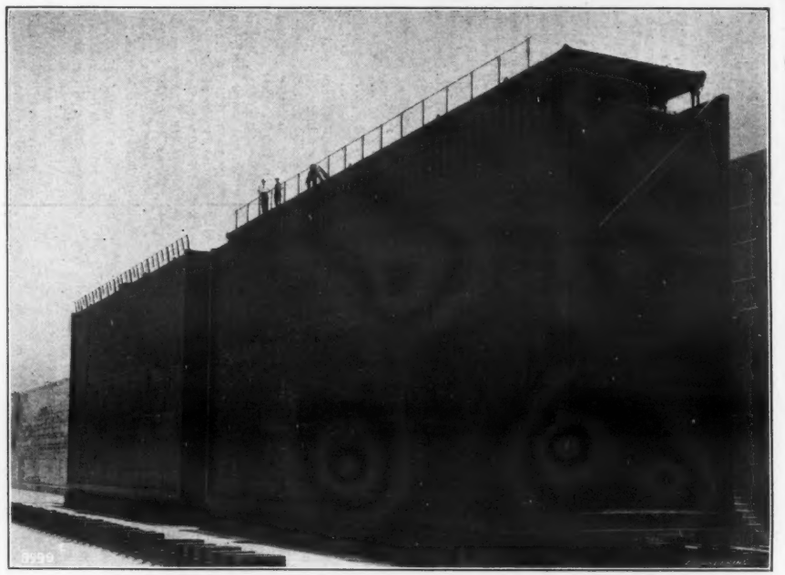


Fig. 35. The Two Caissons Erected Inside the Dock Chamber.

FIG. 32. DOCK CHAMBER, VIEW SHOWING SEATINGS AND ROLLER PATH FOR OUTER CAISSON.

FIG. 33. THE TWO CAISSONS ERECTED INSIDE THE DOCK CHAMBER.

CAISSONS FOR THE DRY DOCK AT CONGELLA, DURBAN, SOUTH AFRICA.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG-WHITWORTH AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, NEWCASTLE-UPON-TYNE.

(*For Description, see Page* 438.)

Fig. 7.

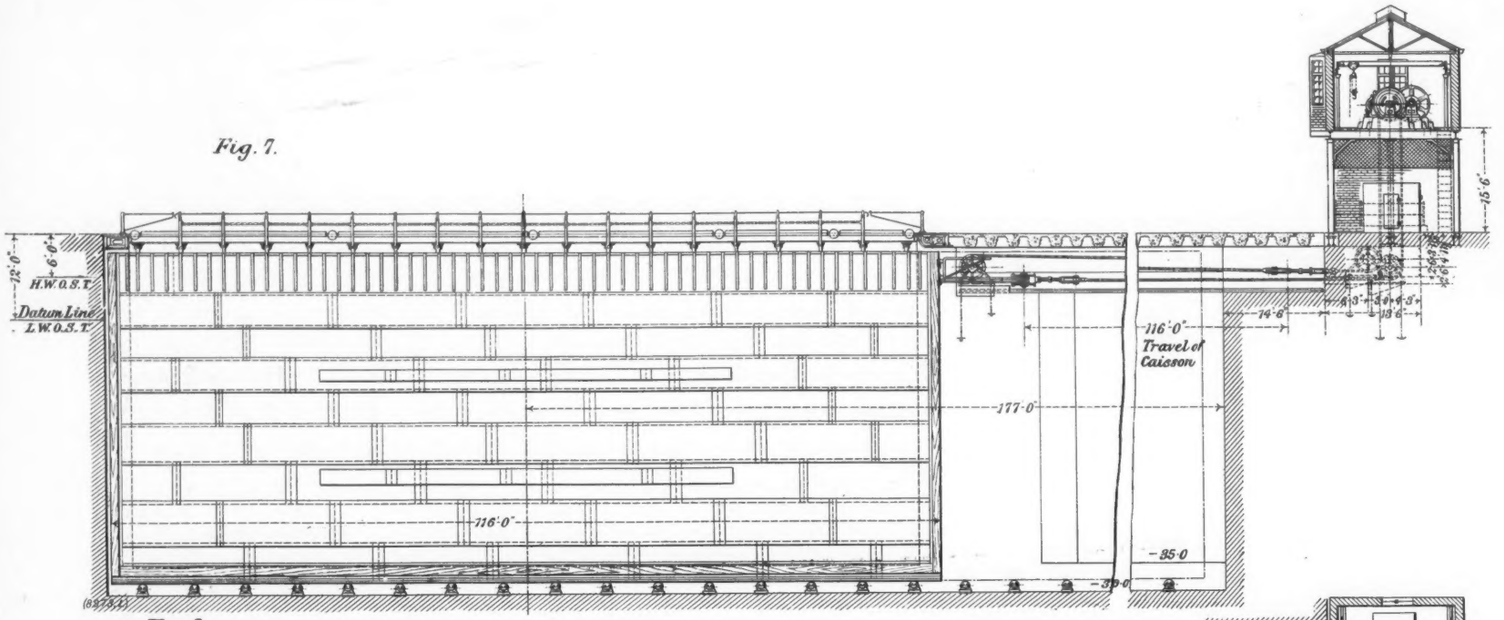


Fig. 8.

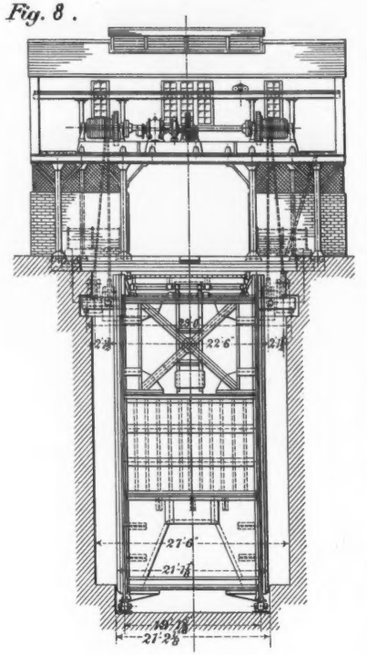


Fig. 9.

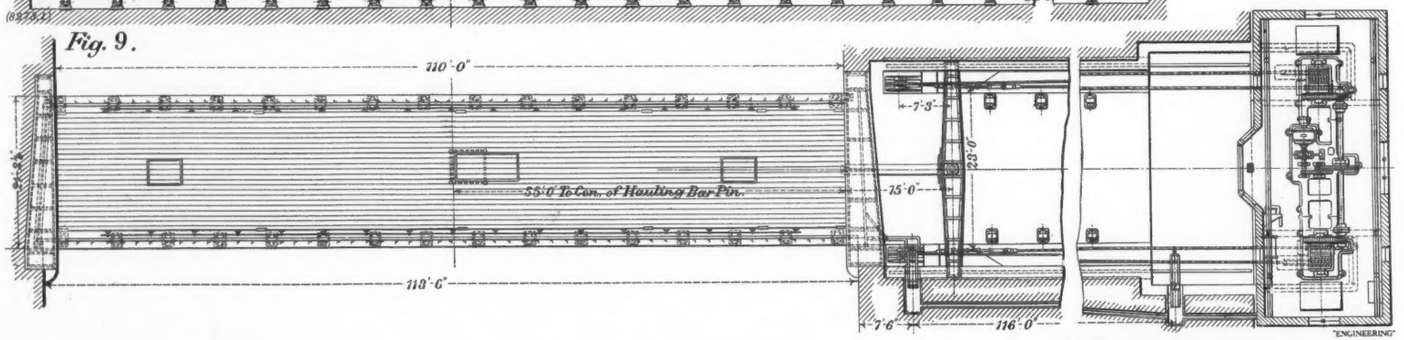


Fig. 10.

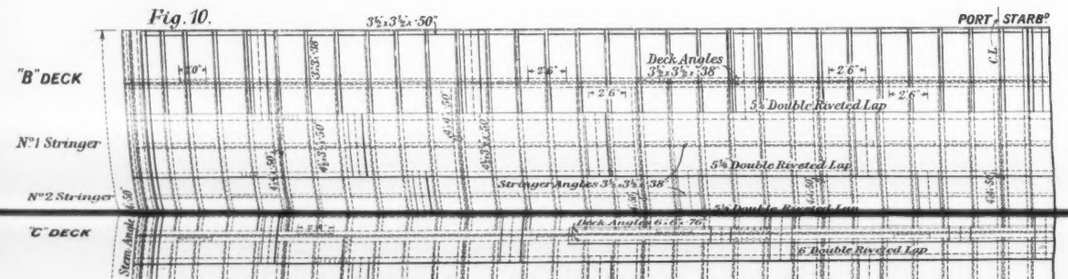


Fig. 11. TYPICAL MAIN FRAME.

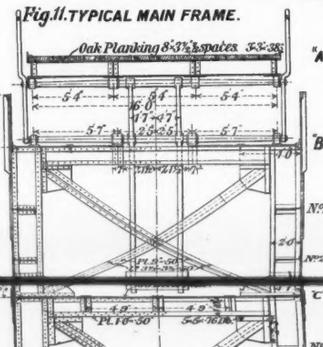
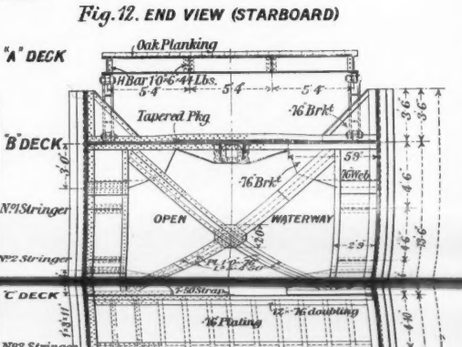
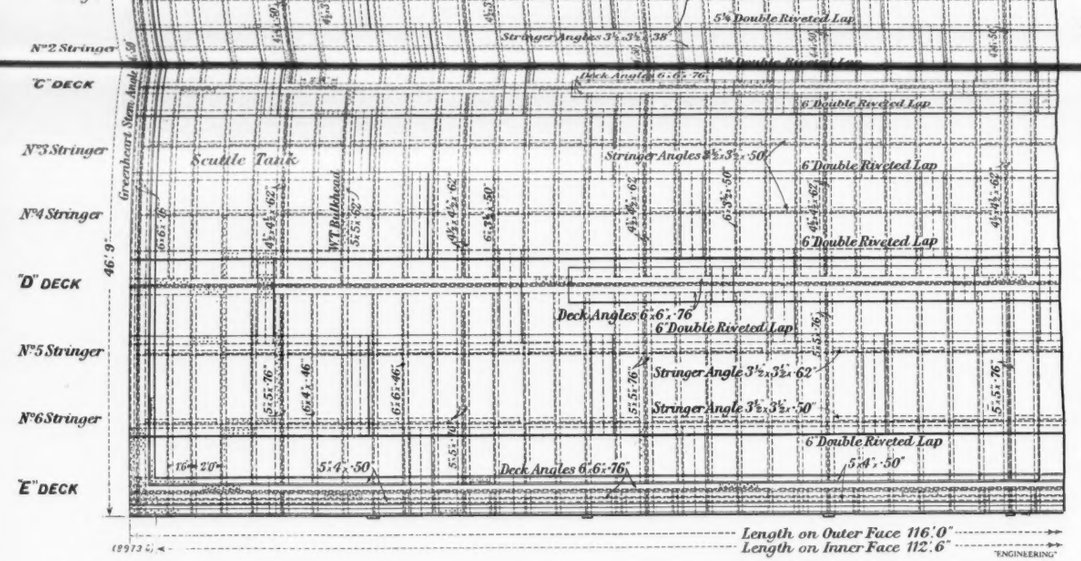


Fig. 12. END VIEW (STARBOARD)





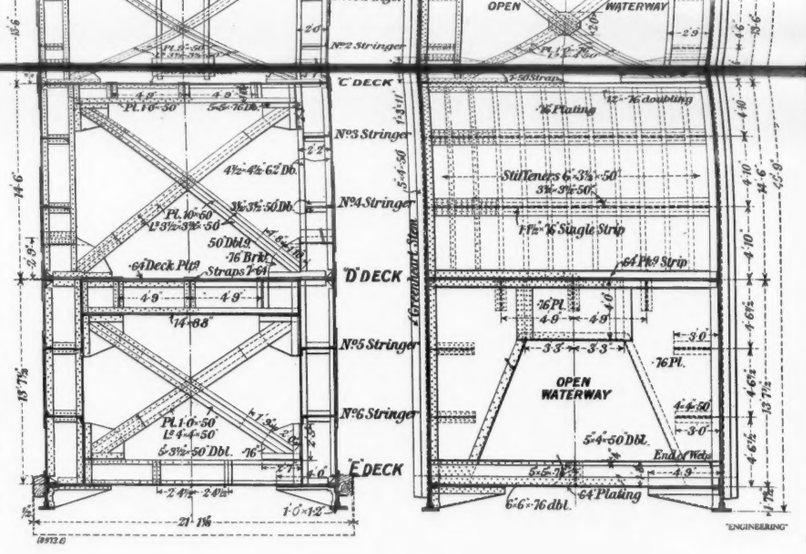


Fig. 13 "B" DECK.

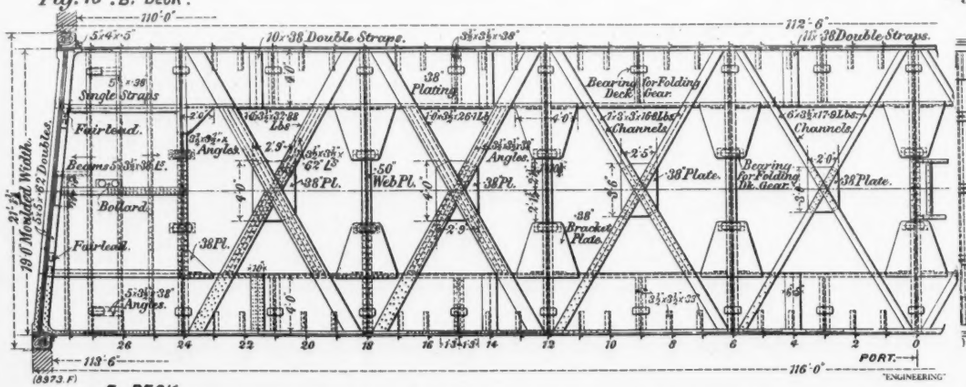
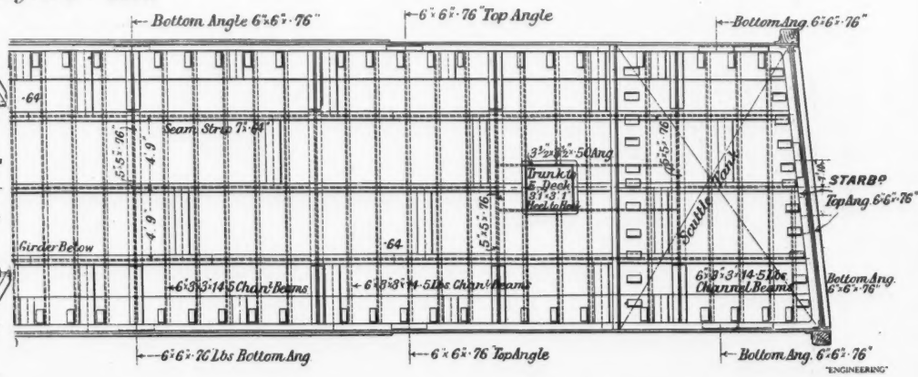


Fig. 14 "D" DECK



E. DECK.

Fig. 15.

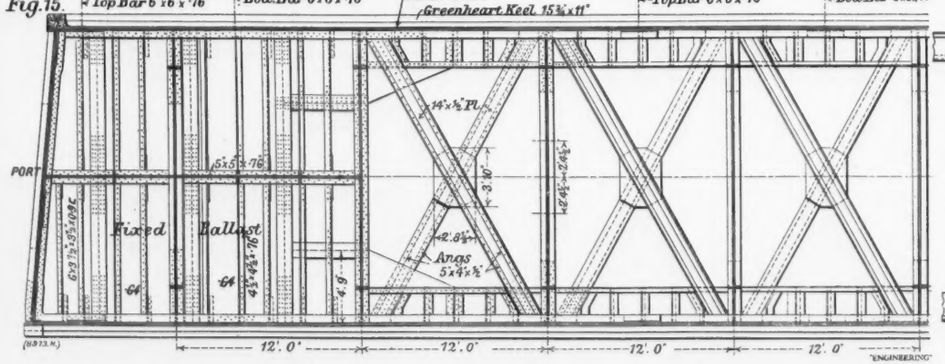


Fig. 16. STRINGERS 3 & 4.

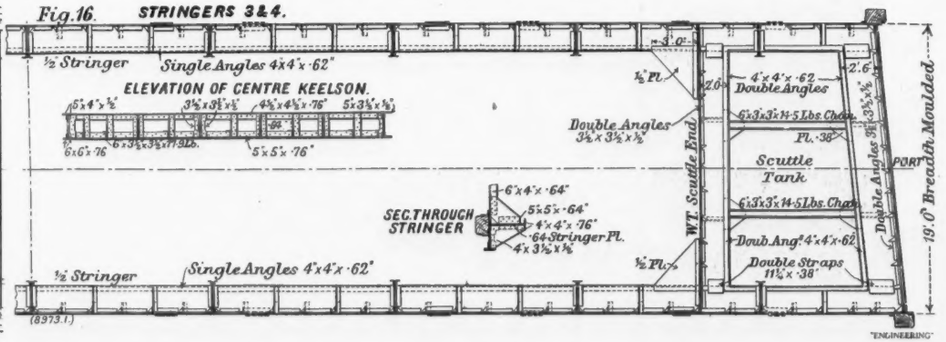


Fig. 17. STRINGERS 1 & 2

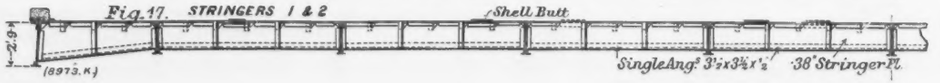
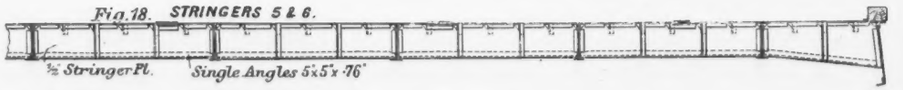


Fig. 18. STRINGERS 5 & 6.



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Two-Page Plate.—CAISSONS FOR THE DRY DOCK AT CONGELLA, DURBAN, SOUTH AFRICA.

ENGINEERING.

FRIDAY, APRIL 10, 1925.

THE CONDITION OF THE ENGINEERING INDUSTRY.

IN its report on the present conditions and future prospects of the engineering industry, compiled for presentation as evidence to the Government Committee of Industry and Trade, the British Engineers' Association has produced a document that deserves careful study. It is, as its title implies, a statement of facts rather than of proposals for action. The effect of the facts is not new, and whatever proposals they may suggest have to be taken in context with other considerations, derived from circumstances that apply not merely to the engineering industry, or that are peculiar to special sections of it. In its conclusions the Association accordingly confines itself to indicating the principal causes of the situation its report describes, and states the remedies it proposes only in general terms. What is most notable in the report is the considerable collection of information on the recent history of the industry, much of which will be new to most engineers. Though it may do nothing to modify their previous view of the situation, it does much to illustrate it from aspects that have not been generally recognised. The impartial and authoritative sources of the information, as well as the unusual clearness with which it is presented, should attract to it the serious consideration of the committee to which it is addressed, and of a still wider public. While special attention is given to "machinery," the Association takes account not only of engineering manufacture and shipbuilding, which it represents directly, but of the allied iron and steel and non-ferrous industries.

Perhaps the most striking illustration of the present position of the industries in question, if one of the most familiar, is the relative extent of unemployment in those industries as compared with what is found in others. A table gives the monthly percentages of unemployed for the eighteen months ending December, 1924, among the 11½ million insured workpeople. The average for all trades at the end of that period—about 11 per cent.—was about the same as in the building trades, distinctly more than in the textile, coal-mining and motor vehicle trades, double that of the printing and allied trades, and nearly double that of the distributive trades. In the engineering and engineers' foundry trades, on the other hand, over one-eighth of the insured workpeople were idle, in the steel trades well over one-fourth, and in shipbuilding and ship-repairing nearly one-third. As the report points out, these figures are by no means an exhaustive measure of the extent of unemployment in the industry or of the injury it involves. Large numbers of young trained engineers of staff rank and many senior men of proved ability and energy are without suitable or perhaps any employment, those who are employed have only restricted opportunities of advancement, skilled men are emigrating, and recruiting by apprenticeship is discouraged. All of these are influences that injure the industry as well as the individuals.

To many people, however, a still more striking evidence of the change in the situation from what it was before the war, will be seen in some of the financial results that the report summarises. In a striking table the leading financial data are given for the aggregate trading of 31 representative engineering and allied firms. On the average for the period 1911–13 these firms had an aggregate paid-up capital of just over 39,500,000*l.*, or an average of about 1,250,000*l.* each; the type of enterprises that, in respect of financal facilities, must have been at least as well off as the average firm. To cope with the requirements of their business these firms in 1923 had a paid-up capital nearly two and a-half times as large as in 1911–13; but, whereas before the war their financial resources were assisted by debentures to the value of about half the capital, their debentures in 1923 were only just over a fourth of the capital. Their dividend in 1923—just under 5 per cent.—was less than two-thirds of its rate in 1911–13. To pay even this they had to distribute about five-sixths of their earned profit, and could carry to reserve only a fourth of the percentage of their capital that they had so allocated in 1911–13, when the actual amount carried to reserve was over half as much again as the sum so treated in 1923 in spite of the far larger capital of that year. The amounts carried forward in each year were the same percentage of the paid-up capital. The report gives similar figures for 1921 and 1922, those for 1924—which at best could only be fractionally better than for 1923—being not yet available.

From these and other facts the Association concludes that "under the conditions now existing, the engineering industry offers no attraction to the new capital required for its progressive development, and that its present tendency is retrogressive." From the entirely independent aspect of the figures for exports and imports the information given in the tables and graphs leads to a similar conclusion. This information is given not only for aggregates of industries, but also in some instances for particular classes of products. To attempt further to summarise its already succinct details would only result in confusion, but some idea may be given of its main indications. They consist of figures both of tonnage and of amount for recent years, as compared with some pre-war period (either 1913 or 1911–13) for which comparative figures are available. In making comparisons of exports, as the report points out, care must be taken to remember that the earlier figures are far from what would be necessary to be satisfactory under existing conditions. The normal increase of population, the enormously increased burden of debt and taxation, and the higher standard of living, call for very large increases over pre-war figures before the community can be in a position to continue its present manner of life. Yet so far from any increase whatever being shown, the course of export trade has shown an almost uninterrupted shrinkage. Only in electrical machinery were exports in 1924 greater than in 1913; and even the increase for that year, when exports were about a third higher than in 1913, follows on figures for 1923 and 1922, when they were lower than in 1913. In 1922 they were actually about a third lower than in 1913. For machinery as a whole the exports of 1924 were little more than two-thirds of those of 1913, and for iron and steel manufactures under four-fifths. The imports of all metal products in 1924, on the other hand, were much the same as in 1913, while those for machinery and vehicles (a total

for which the exports were, as for machinery alone, about a third less than their volume in the pre-war year) were nearly a third more. It is remarked, moreover, that the value of the imports is about 50*l.* per ton (some 25 per cent.) higher than that of the exports, showing the much greater amount of manufacture included in the imports.

The analysis of the markets in which these changes had come about shows some remarkable fluctuations. The most interesting of these relates to the course of trade with British possessions. In 1924 over half the export trade in machinery went to British possessions, about two-thirds of it being for India, whereas in 1913 only about a third of the exports for the year went to these markets, and less than one-half of that quantity went to India. Leaving Germany and Russia out of account, exports of machinery to Europe in 1913 were more than half as large again as in 1924, and to South America were, in 1913, three times what they were in 1924. The investigation made by the Engineering and Allied Employers' National Federation is quoted by the report under notice as putting the average volume for 1923 and 1924 of home and export trade at figures that work out at nearly 3 to 1, which indicates an approximate estimated increase of about one-half in total production. This increase is far from being proportionate to the increased productive capacity of the industry, and the greatly increased burdens it has to bear; and the competition of foreign countries under conditions that handicap home works unfairly has prevented the trade from giving satisfactory financial results.

The net outcome of this discouraging history is familiar. In the Association's view no solution of the difficulties in which the engineering industry now finds itself, can be found until costs of production and distribution are reduced through the willing co-operation of capital, administration and labour. A truce in industry doubtless is the first essential to the recovery of trade, but it would be of little value unless it led to a prolonged peace. The present balance of efficiency in the engineering trades is against us, and in favour of our competitors, and our share in the world trade in manufactured articles will suffer till the balance is redressed. If, indeed, means cannot be found to do more than place our productive efficiency on an equality with that of our competitors, the proportion of our financial resources now applied to non-productive purposes must be reduced, as the report suggests, "having regard to our heavy load of debt and the needs of our wealth-productive industries on which the national solvency finally depends." The Association indeed calls for such reduction without any such proviso, and in this it may well be right. It is certain that not merely our share of the world's orders, but also its absolute amount by which the value of that share is determined, depends on the improvement of productive efficiency. Any student of the report, whether among manual workers or administrators, must see that, apart from such improvement, the industry has no resources within itself that can remedy the situation, and no prospect except to go from bad to worse.

THE TESTING OF AGRICULTURAL MACHINERY.

SPRING has been proverbially regarded as a time of rejuvenance, and it would almost appear that this feeling is not confined to mere private individuals, but also permeates the Ministry of Agriculture and Fisheries. At any rate, we like to think that it is more than a mere coincidence that not only have the various advisory committees on agricultural machinery been appointed at this time of year with one exception, but that they have also been moved to issue their reports in the same period. It will be recalled that a committee was appointed in 1919 to arrange for the testing, adaptation, and improvement of machines likely to prove of value to agriculture, and that in 1921 a second committee was appointed to advise the Ministry more particularly with regard to testing only. We referred at some length to the findings of these two committees in our issues of April 30, 1920, and April 27, 1923, and need not cover the same ground again. The scheme of work proposed by the second committee covered two types of investigation. The first of these was termed a series investigation, and was intended to be a short test of a number of different machines performing the same operation under similar conditions; while the second, termed individual tests, were to apply to a particular machine only, and were to be extended over a much longer period. A third committee was appointed in May, 1924, to advise the Ministry on the conditions which should govern the latter type of test, and the report of this committee has just been issued. In view of the period which has elapsed since the matter was first taken in hand, it comes as somewhat of a shock to discover that one of the recommendations of the third committee is for the Ministry to appoint a fourth, but it is somewhat of a relief to find it suggested that the latter should be permanent, as by this means the country would be spared the possibility of an infinite series. We would hasten to add that the appointment of a permanent committee appears to be a very necessary step, but that it might equally have followed the findings of the committee of 1921, as the provision of a small permanent testing staff, assisted by an advisory committee, was amongst the recommendations of that body. When dealing with the matter in 1920 we discussed the comparatively small extent to which engineering was concerned with agriculture, and as the proportion has not substantially increased since that time, we imagine that the bulk of our readers will have but a hazy notion of the issues which have been before the various committees appointed by the Ministry.

With minor exceptions, the history of British agriculture in recent years has been one of struggle against adverse economic conditions. There is a natural tendency to draw a parallel between this and other industries, and to apply the general conclusion that economic salvation can only be attained by the application of power-driven appliances in place of manual or equine labour. There is undoubtedly a measure of truth in such an application of economic law to agriculture, but the parallel between this and other industries can easily be overdrawn. We can recall no other industry in which the weather is the dominant factor in determining success or failure, and our heritage of almost innumerable small holdings introduces a factor which is directly opposed to one of the fundamental principles of economical mechanical operation. Apart from these considerations, the nation has recently had occasion to realise in the case of another of our great industries that the most economical methods of production at home may fail to outbalance the advantageous conditions enjoyed by our competitors abroad; and it would appear that the international economic balance has swung against British agriculturists in recent years with somewhat undue frequency. In a non-essential industry, the natural result of adverse economic conditions is the gradual transfer of the centre to a country which is more favourably situated, but we believe that the opinion is universal amongst the people of Great Britain that the retention of agriculture in these islands is essential to the national security. Under these circumstances the disabilities to which we have referred serve only to strengthen the case for utilising every known method of assisting the farmer.

The extent to which mechanical appliances can be employed advantageously in farming operations is a matter of opinion, but it is obvious that farm proprietors should have the fullest opportunities of investigating the possibilities in this direction, and should be kept in touch with any developments that take place. With this object in view, the Ministry of Agriculture, the Royal Agricultural Society, and the Society of Motor Manufacturers and Traders have all organised exhibits and competitions of agricultural machines from time to time, but these have for the most part been of short duration, and a very trifling mishap to one of the competing machines has been apt to give an entirely false idea of its reliability. It is on this account that the long-period tests to which we have referred have been recommended by the various committees appointed by the Ministry. Without such tests the farmer has little or no opportunity of correcting an erroneous impression resulting from a trivial failure, as the very nature of his work places him in an isolated position. In a somewhat parallel case, that of the motor industry, the failure of a car in a short trial may be offset by the favourable experiences of a large number of users, but the limited extent to which power plant can be employed on British farmsteads militates against the accumulation of common knowledge of any particular machine in this way.

The committee which has just issued its report has outlined its proposals for future tests in considerable detail, and states that as a result of such tests it should be possible at no very distant time to set up scientific standards of efficiency by which the work of the more important machines and implements may be judged. The establishment of such standards would undoubtedly be of the greatest value, and although, in view of the known difficulties, the conclusion of the committee which we have quoted may appear somewhat optimistic, it is presumably based on the evidence of experts on the various issues involved. In the report, provision has been made for carrying out short and long-period tests. The former would be less costly, would only last a few days, and would enable the demand for early reports to be met. The long-period test would extend over a period corresponding to the time or season during which a machine or implement is used in the course of the farming year, and it is presumably on this type of test that scientific standards of efficiency would be based. In commenting on the general principles of testing to be adopted, the committee propose that mechanical testing should be undertaken first in the laboratory, where the design, material, friction losses and other features will be determined; and afterwards in the field under working conditions, where the drawbar load, adhesion, degree of soil disruption and similar points would be investigated. Concurrently with the latter tests it is proposed that the physical factors involved would be recorded. These are tabulated as the soil density and moisture before and after the tests, and the plastic deformation and degree of disturbance of the soil. The laboratory tests clearly offer no difficulty, but before any standards of efficiency could be deduced from the field tests, it will not only be necessary to establish basic constants representing the characteristics of a wide variety of soils under varying climatic conditions, but the relation which these constants bear to the leading characteristics of the machines must also be determined. To take again an illustration from motor vehicle practice, in estimating the relative performances of different cars, the nature of the surface on which they are operating can usually be ignored, since it is easy to run all the competing vehicles over the same surface, or, alternatively, to assume that all the surfaces are so nearly similar as not to affect the performance of the vehicles appreciably. In the case of agricultural machines, neither of these alternatives is practicable, and the test is further complicated by the fact that not only is it necessary to ascertain the effect of the nature and surface of the soil on the performance of the machine, but the effect of the machine on the soil has also to be investigated.

As we have previously stated, the report suggests the appointment of a small permanent committee to assist the Ministry in carrying out the testing scheme. It is proposed that, in addition to representatives of the Ministry, representatives of the agricultural, engineering and farming industries, and of scientific bodies engaged in agricultural engineering or allied problems, should be included. The suggested terms of reference for this committee are intended to ensure that the conditions of test are suitable, that the test is conducted in an efficient manner, and that the certificate and report issued are strictly impartial and embrace all salient facts. In commenting on the report of the second committee, appointed in 1921, we suggested that when a permanent committee was constituted, it should include a representative of the Institute of Mechanical Engineers. We gave our reasons for this proposal sufficiently fully at the time, and our opinion on the

value of such an inclusion has in no way altered in the interim.

The report includes a number of appendices, comprising proposed forms of entry, specimen certificates, and outline reports for various classes of machine. A proposed schedule of fees to be charged for various tests is also included.

THE INTERNATIONAL PATENT CONVENTION.

IT is well known to almost all inventors—and certainly all patentees—that there has existed for many years an arrangement between the principal patenting countries by which an applicant for Letters Patent in one country may receive certain rights of priority when filing an application in respect of the same invention in any other of this union of countries. The Convention, which is for the international protection of industrial property, has been the subject of revision, particularly at Washington in 1911, and is now to the front again because a commission is to sit shortly on the Continent to consider what alterations, if any, should be made to the terms of the Convention having regard to the experience gained in its working. It is desirable that this should be known in order that patentees may bring forward in a suitable way such points as may have affected them in their experience of procedure under the arrangements between the countries involved.

One of the most important provisions of the Convention is that an applicant in one of the countries may enjoy a period of twelve months before filing in the other countries, and retain in all the union countries the priority of his first filing date in the country of origin. For some years this was a reasonable period, especially having regard to the fact that a search has been made since 1905 of all complete specifications filed in the British Patent Office, the results of this search being available in a reasonably short time, whereby the inventor is enabled to get some idea of the prospects of obtaining a patent in foreign countries before the expiry of the term of grace allowed by the Convention. If the British search showed the application to be wholly anticipated, clearly it would not be worth while filing abroad. Since the war the time taken for the British Patent Office to make its search, especially in some branches, has very materially increased owing to the heavy work thrown on the Office. In addition the time for filing a complete specification has now been extended from six months back to nine months, which was the period allowed in the days before searches were instituted. If, therefore, an applicant avails himself of the full period of nine months—which is commonly done, although all applicants do not realise that it is not essential to take this time—then the results of the British search are by no means likely to be available in time for filing abroad within the one-year limit.

One question which needs consideration, therefore, is whether it would be wise to extend the period of one year to take into account changed conditions. This brings into view another important factor, namely, the position of those who may have begun to manufacture in the interval between the date of filing in the country of origin and the date of filing in some other country in the union, claiming priority under the Convention. The Convention as it now stands safeguards the rights of third parties, but it is by no means clear what the term means, and whether it has the same effect in all countries. It certainly seems that practice is different in this country and abroad in this respect. If the period of priority under the Convention be substantially extended then it is very important to define the rights of third parties.

Assume that a manufacturer begins to make an article in this country, he may be faced at the end of many months with a patent based on an application claiming a long term of priority under the provisions of the International Convention. It appears that he may have no rights in his manufacture and, notwithstanding the expense to which he may have been put in the way of plant, it seems that he would be forced to stop manufacturing after the patent had been granted in this country to the foreign applicant. One reason for this seems to be that in England a patent dates from the date of application or the date of filing abroad when applied for under the International Convention, and redress for infringement can be obtained after the date of acceptance of the complete specification, although the suit may not be brought until the patent has actually been granted.

As the patent runs from the date of the first application. the period of priority comes within the term of the patent and, in a sense, it therefore appears inequitable to the now patentee to say that what an English manufacturer has started to make before the equivalent of the foreign application was filed in this country, should be permitted to continue without payment of royalties. The point of view of the English manufacturer is clear, namely, that to him it is unfair that he should be stopped from continuing to make what he innocently did when no patent application had been filed. The longer the period of priority allowed by the Convention, the more important becomes this question of the rights of third parties. In connection with this point it is also necessary to bear in mind the large part of the patent term which is practically lost to applicants under the International Convention when a patent dates from the date of application in the country of origin and not from the date of grant.

Another matter which frequently gives rise to difficulty is that of the requirement which appears to be involved in the Convention, that the date for filing in any country of the union, is one year from the date of filing the first application for the same invention in any other country of the union. It has been suggested that it would be well if an applicant were free to choose any country as the basis of his filing in any other country within the union, and not necessarily the country of origin. At the present time the anomalous position exists that the filing in a country outside the union does not count in respect to the period of priority which may be obtained under the Convention, but the filing of the first application in a country within the union must be taken as the basic date for the filing of other applications.

Many other points will occur to patentees who are accustomed to file foreign applications. These matters require careful consideration at the present time.

NEW ZEALAND TRADE.

THE prosperity of New Zealand is entirely dependent on its pastoral and agricultural industries. A report on the economic and commercial conditions in the Dominion prepared by Mr. N. Elmslie, recently issued by the Department of Overseas Trade, states that, in spite of somewhat adverse weather conditions during the past year, there has been steady progress in trade. The total exports for 1923, consisting chiefly of wool, frozen meat, dairy produce and hides, amounted to 45,371,908*l.*, an increase over the previous year of 3,672,740*l.* The exports for the first six months of 1924 totalled 33,293,366*l.*, an increase of 2,487,760*l.* over the corresponding period of 1923. Imports, consisting mainly of manufactured goods of all descriptions, amounted to 43,378,493*l.* in 1923, as compared with 35,012,561*l.* in 1922. Although returns for the first six months of 1924 show that importation is proceeding at the same high rate, it is pointed out that trade is steady and that the general prosperity and consuming power of the country enables it to carry high stocks.

Imports of textiles amounted to 4,882,322*l.* in 1922, the United Kingdom supplying 79·2 per cent. of the total, the figures for 1923 being 6,175,813 and 81·9 per cent. respectively. Australian pits supply practically the whole of the coal used in New Zealand, although "owing to special circumstances," considerable quantities were purchased in the United Kingdom during the years 1921 and 1922. Trade in iron and steel bar and rod is increasing rapidly, the United Kingdom contributing 94·32 per cent. of the 1923 total of 22,462 tons valued at 293,325*l.* Australia, which contributed more than 30 per cent. of the trade in 1920 and 1921, only held 0·6 per cent. in 1923, and the share of the United States dwindled from 16 per cent. in 1918 to less than 0·5 per cent. in 1923. Imports of pig-iron in 1923 were double the 1922 tonnage, and the value rose from 31,089*l.* to 56,864*l.*; the United Kingdom supplied 51·2 per cent. in 1922 and 58·4 per cent. in 1923. Imports from India are increasing, while those from Australia are decreasing. The former country supplied 19·3 per cent. of total requirements in 1922 and 28·1 per cent. in 1923. Australia, which furnished more than 50 per cent. of the trade in 1920 and 1921, supplied less than 1 per cent. in 1923. Non-ferrous metals are obtained chiefly from Great Britain, with the exception of tin and lead, which are imported almost exclusively from Australia. The trade in metals "manufactured other than machinery," increased from 4,249,178*l.* in 1922 to 4,984,861*l.* in 1923. The United Kingdon supplied 76·0 per cent. of the total requirements in 1922 and 72·7 in 1923, the most serious competition coming from United States manufacturers, who increased their imports from 456,332*l.* in 1922 (10·7 per cent. of the total) to 599,523*l.* (12 per cent. of the total) in 1923.

Owing to the fact that trade relations with Germany have returned to the normal, German goods have re-appeared on the market, and this trade may become an important factor in the course of time. The trade in bolts and nuts, brass and copper pipes, sheets and plates, cutlery, hardware, angle and sheet-iron, and tubes, pipes and fittings is in a satisfactory position so far as this country is concerned, United Kingdom firms supplying the great majority of the requirements. Imports of railway and tramway materials showed a marked decrease over previous years, which, however, is only regarded as temporary. British manufacturers are, on the whole, maintaining their position, but United States firms have supplied a considerably larger share of the requirements in wagons, cars, &c., than has formerly been the case. Considerable quantities of wire goods are imported and although much of the trade is in the hands of United Kingdom manufacturers, imports from Canada and to a lesser extent from the United States are steadily increasing. In the matter of plate and plated ware, it is interesting to note that Welsh tin-plate is maintaining its supremacy, this being due partly to lower price and partly to the preferential rate of Customs duty now in force.

Tools and implements are supplied almost entirely by British and United States firms, and it would appear that the latter are gaining trade at the expense of the former. Imports of machinery were valued at 2,769,325*l.* in 1922, and 3,007,509*l.* in 1923, The United Kingdom supplied 63·6 per cent. of the total in 1922 and 59·7 in the following year. The report states that while British manufacturers are holding their own in most important lines, there have been decreases in importations from the United Kingdom of agricultural and dairying machinery, electrical machinery, and gas and oil engines. This is attributed to the fact that British agricultural machinery is not as well known as it should be; again, in the matter of dairying machinery, local manufacture supplies a considerable portion of the requirements. Imports of electrical machinery from Canada have greatly increased during the past three years, and should the present rate of increase continue, the North American Dominion will become the most serious competitor for this class of trade. Rather more than half the trade in gas and oil engines, amounting to 12,600*l.* in 1923, is in the hands of the United States, England coming second with 9,813*l.*, the total value for the year being 22,965*l.* Of industrial machinery of all kinds, including printing machinery, grinding mills, bone crushers, typewriters, sewing machines and similar items, valued at 400,000*l.* in 1923, Great Britain supplied rather more than 60 per cent., a proportion which Mr. Elmslie states might be improved upon.

The percentage of British motor vehicles imported by New Zealand has fallen far below the 1914 figure, but in this direction matters appear to be improving. The United Kingdom holds only a very small proportion of the trade in motor tyres; the United States comes first with 41·8 per cent. of the total imports; Canada second with 29·4 per cent.; France third, with 11·8 per cent.; the United Kingdom fourth, with 7·2 per cent.; and Italy fifth, with 6·6 per cent. It is encouraging to note,

however, that the British motor-cycle is gaining in favour.

Loss of trade to British firms through "lack of knowledge of the market, failure to give 'service,' inefficient advertisement, and inadequate attention to selling organisation" is a matter with which the report deals at some length. Criticism of this kind does not apply to all classes of trade nor to all suppliers in any class, but a close investigation into the business procedure of the Dominion and the requirements of the inhabitants of New Zealand will not only prove of great advantage from a commercial point of view, but will further enhance the prestige of British firms.

The New Zealand State Railways recently instituted a policy of rigid economy coupled with improvement in organisation, and the financial year ending March 31, 1924, showed a marked increase in receipts and a considerable decrease in expenditure. Improvements are being pushed forward and this taken in conjunction with the development of arterial roads, another matter receiving attention, will do much towards opening up new country and will lead to more extensive production and closer settlement.

The re-introduction on October 1, 1923, of the "penny postage" to all parts of the Empire and to certain foreign countries is a noteworthy feature, and denotes a progressive spirit on the part of the authorities. The telephone system has also been reorganised and extended with the object of stimulating development.

The Department of Public Works is devoting much attention to hydro-electric development. Several installations are rapidly approaching completion, and others are under construction. Sir W. G. Armstrong, Whitworth and Co., Limited, recently secured the contract for the development of 45,000 kw. at Arapuni, an installation which, it is estimated, will require three years to complete.

The cost of living within the Dominion has fluctuated greatly during the past four years. In June, 1924, the index figure for food stood at 49·91 per cent. over July, 1914, prices. Clothing and footwear prices have fallen steadily since February, 1921, but in other directions, notably in the matter of "rent," a rising trend is indicated.

The proposal to hold an international exhibition at Dunedin during the summer of 1925–6 is a matter of some importance to the commercial world and should prove of the highest value, to New Zealand trade. A fund of 100,000*l.* has been raised to finance the undertaking, a quarter of which has been contributed by the Dominion Government; a site of some 65 acres has been acquired and building operations have commenced. The project is an ambitious one, but it is evidence of the general prosperity of New Zealand and an earnest of future trade expansion.

THE LATE SIR WILLIAM M. ACWORTH.

SIR WILLIAM MITCHELL ACWORTH, who, so far as this country is concerned, might perhaps have been considered as *the* authority on railway economics, died in London, on Thursday, April 2, as the result of an illness following a seizure which overtook him some weeks earlier, whilst lecturing at the Workingmen's College, St. Pancras. Born at South Stoke, Bath, in 1850, Sir William was in his 75th year at the date of his death. He was educated at Uppingham and at Oxford, and after leaving the university served for 18 months as tutor to the ex-Kaiser and his brother. He then became a master at Dulwich College where he remained till 1885. He was called to the bar in 1890, and became a Parliamentary Counsel. His interest in railways appears in the first instance to have lain mainly on the technical and historical side, having been aroused by a perusal of Francis's "History of Railways."

For generations past English people have grown up with railway facilities comprising one of the commonplaces of existence, and if familiarity has not exactly bred contempt, it has at least prevented most of us from realising how remarkable a great railway undertaking really is. Acworth started with an appreciation of this truth, and his earliest writings on the subject were concerned mainly with this aspect of the railway system. In 1891, however, in his work on "The Railways and the Traders," he entered into the field of railway economics. This work was not wholly agreeable either to the companies or to their customers. His demand for a fuller publication of statistics was far from palatable to the managers, who foresaw that in meeting it they would be preparing a rod for their own backs, and that any figures published would be misunderstood and misinterpreted by a legion of fluent publicists. On the other hand, Acworth showed the impracticability and absurdity of plausible proposals for fixing rates evolved by various amateurs on the basis of *a priori* assumptions. The whole matter was further developed by him in his treatise on "The Elements of Railway Economics." This was first published in 1904, and was based on courses of lectures he had delivered at the London School of Economics. A second edition, revised and somewhat enlarged, was published in 1924. In this work the author pointed out the impossibility of fixing rates on the basis of cost, and showed that in many instances such a basis would mean an increase of charges for inland freight and a reduction of charges for imported goods.

The value of his work was rapidly recognised, and in 1899 he was appointed a member of the Royal Commission on Railway Accidents, and in 1906 of the Viceregal commission on Irish Railways. In the same year, moreover, he served on the Board of Trade Committee on Railway Accounts and Statistics. This led to fuller figures being required from the companies, but the requirements fell a good deal short of what Acworth desired. The additional changes made just before the war, however, did give him substantial satisfaction.

His wide familiarity with railway history made him a strong opponent of railway nationalisation. Nevertheless, when in 1916 he was called in to report on the disastrous state of the Canadian railways, when the Canadian Northern and Grand Trunk lines were threatened with bankruptcy and the Inter-colonial line was as usual running at a loss, he did not hesitate to recommend government ownership as the lesser of two evils. From this opinion, a fellow commissioner, Mr. A. H. Smith, of the New York Central dissented, and it is possible that the one attached more importance to the immediate conditions, and the other to ultimate results. To minimise the drawbacks attaching to Government ownership, Acworth advocated a commissioner system, somewhat on the lines originally adopted in Australia; in order "to take the railways out of politics." The Australian precedent, however, provides little hope that this desideratum can be permanently maintained in a democratic country. In 1917 he gave evidence against government ownership to a joint committee of the United States Congress, and the substance of this was subsequently published in an "Historical Sketch of State Railway Ownership." In 1918, he conducted an inquiry into the policy and administration of the Rhodesian Railways, and in 1920 he acted as Chairman of the Committee on Indian Railway Policy and Administration. As a reward for this work he was knighted and given the K.C.S.I. In 1923 he conducted for the League of Nations an inquiry into the Austrian railways, and in 1924 he carried out similar work on the German Railways for the Reparations Committee.

NOTES.

NON-FERROUS METALS RESEARCH.

THE number of non-ferrous metals and alloys in ordinary commercial use is so large that an enormous field lies available for investigation and research. So much is this the case that difficulty is more likely to arise in deciding what problem should first be tackled than in finding valuable work to do. In the capable hands of the British Non-Ferrous Metals Research Association any investigation undertaken is likely to be of value, but it is certain that that body would have no difficulty in enlarging the scope of its works were the necessary funds to become available. The association is already supported by a large number of our important metallurgical and engineering firms, but the work in which it is engaged is of such great importance to many organisations falling within this latter class that support by a considerably larger number might reasonably be expected. The association has now been in existence for five years, and the scope of its activities is well illustrated by the fact that during that period approximately 20,000*l.* has been provided by members' subscriptions and a further 20,000*l.* in grants from the Department of Scientific and Industrial Research. That the funds are being spent well is illustrated by the fact that in 1924 81½ per cent. of the total expenditure was devoted to experimental work. Operations on a scale of 16,000*l.* to 20,000*l.* a year are planned for the future, and the initiation of the new programme has been facilitated by promise of a further 10,000*l.* from the Department of Scientific and Industrial Research. This sum is to be spread over five years in gradually decreasing amounts, and it is confidently hoped that further assistance from those who directly benefit will more than meet the difference in coming years. The association has been fortunate in enlisting the co-operation of the great railway companies in connection with its research on fire-box stays, and it may reasonably be hoped that other great organizations interested in engineering work will in due course lend their aid and support. A very prosperous future may be anticipated under the direction of the new Superintendent of Research, Dr. Hutton, who was appointed in September last.

FIRE PRECAUTIONS.

Among the fables once used for the instruction of children was one concerning a penniless student who carelessly broke his water pitcher and who thereafter had to handle it with extreme care. The lesson which it was intended to convey was that if he had taken a little sooner only a fraction of the trouble and precautions he was compelled to take subsequently, the accident would never have happened. A similar lesson is implied in the Accident Prevention Pamphlet No. 5 issued by the National "Safety First" Association. The pamphlet is on the subject of fire precautions in the case of new and existing buildings. It states, amongst other recommendations, that when laying out a new factory the various departments should be planned in such a way that the carrying out of hazardous processes shall be confined to separate buildings or, at least, to separate floors of fire-resisting buildings. Walls should be of hard burnt brick, or cement concrete in which a coke-breeze aggregate should be avoided. Stone walls are undesirable features since they crumble under the combined effect of heat and water. Roofs should be built as strongly as possible, and of incombustible material; where glass is necessary, wired glazing should be used. Floors should be of concrete or ferro-concrete, but it is quite safe to lay a wood flooring flush on the concrete—that is to say, without leaving an intervening air space below. All structural metal work in floors, and all columns and stanchions supporting floors should be encased in plaster cement or concrete, as otherwise the strength is rapidly reduced on the application of heat. Other recommendations cover the provision of lifts, hoists, stairways. Much can also be done to reduce fire risks in the case of existing buildings. The filling or partial filling of intervening spaces between such buildings with inflammable stock, stagings, lend-to sheds of inferior construction, &c., is strongly deprecated. If gangways are absolutely necessary they should be constructed, or reconstructed, of incombustible material formed of concrete slabs, or corrugated iron on a steel framework. All these and other precautions enumerated in the pamphlet are intended to reduce fire risks, and, therefore, the premium charged by fire insurance companies. In order to obtain a concession on the insurance premium these companies are accessible for consultation prior to the erection of new buildings or alteration of existing ones. Internal arrangements are also reviewed from the point of view of safe and adequate lighting and heating. It is recommended that all the electric wiring should always be strictly in accord with the rules of the Institution of Electrical Engineers.

Sound advice is also given for the guidance of employees in business premises, especially those which have to do with inflammable material. The advice given in the pamphlet is sound, and, if acted upon in time, is sure to prove beneficial to all immediately concerned, as well as to neighbours, and also to the general public. The pamphlet deserves wide circulation. While it contains little that is novel, the wide dissemination of knowledge on these matters is extremely desirable, and the Association's effort deserves commendation.

LETTERS TO THE EDITOR.

TRAINING FOR THE ENGINEERING PROFESSION.

TO THE EDITOR OF ENGINEERING.

SIR,—The International Labour Office of the League of Nations has issued from Geneva a most informative and instructive brochure on the status and training of the engineer. The author, or authors, have dealt very fully with the whole question of training for the engineering profession as offered by the universities and technical colleges of the world, and state that: "One fact must be noted, however, the general tendency to adapt teaching to the needs of industry. Universities for long regarded the production of teachers as their main task; to-day, however, in most countries they are endeavouring to get into closer touch with industry, in order to meet its needs." Again, the following statement is made: "Industry stands in need far more of practical and human qualities than of theoretical knowledge. An engineer is always more or less a leader of men, he is rarely an office worker. The human worth of this kind cannot be guaranteed by any certificate."

If these findings are accepted in this country in the spirit in which they are written, is it not too much to hope that our own universities and colleges will remodel their old-fashioned methods, scrap their antiquated plant, and attempt to offer to the young men of this generation opportunities which will meet the clamant call of industry and help this country to maintain its place in the struggle for commercial supremacy.

The mechanical tripos of our older universities is to be commended, but the engineering industry to-day requires men with more than the purely scientifically-trained mind. The industry needs men who have shared the load of the toiler in the workshops, who, in the common task have produced goods for the market, who have acquired an understanding into the conditions of labour, the marketing of goods, exchange values and, most of all, leadership of their fellow-men.

Our cousins over the seas in that great hive of industry, the United States of America, have long realised that men of this type are the keystones of industrial prosperity. Their colleges and universities have been more ready to adapt themselves to the needs of the time, and from the old-fashioned method of a long college career followed, or preceded, with practical training in the workshops have developed a more intensive form of training whereby students receive academic instruction and practical training coincidently throughout their career. In other words, the question of practical training before or after college training, within or without college precincts, has been solved and an attempt made to meet the requirements set out by the authors of the pamphlet under review.

In this country many attempts at so-called sandwich systems of training have been made, but the problem has only been tackled thoroughly by one institution. Loughborough College, in Leicestershire, offers academic training of university rank at the same time as practical training in an instructional factory within the college. This factory has accommodation for 300 men and is equipped with every kind of modern machine-tool plant and work is carried out on a productive basis for the commercial market. At the present time approximately 200 young men are in training qualifying themselves for the higher posts in the engineering industry, and it is interesting to note in passing that during the current trade depression the authorities cannot find sufficient graduates to fill the vacancies offered to Loughborough men. For eight years this college, with the enthusiastic support of large numbers of employers in the engineering industry, has been training men to fulfil the conditions laid down in the brochure issued by the Labour Office at Geneva.

The system of training adopted nullified the objections raised by the many against the sandwich system of training, where students spend the winter term in college and the summer term in the workshops, or one year in college and one year in workshops. In both these instances there is the tendency to cause a definite break in both forms of training. The system of training adopted at Loughborough allows a student to attend in the laboratories and lecture rooms during the course of one week of 30 hours, and each alternate week of 40 hours in the workshops. The practical experience in the workshops is gained under exactly similar conditions to those pertaining in any industrial undertaking. The time-keeping is recorded by time clocks, workman's time sheets are maintained, and overtime and time deductions are all standardised in accord with the best modern practice. The students themselves feel that training of this character is of very real value and they rise to the occasion and not only become capable in production, but trustworthy workmen. In the later years of a student's career an opportunity is given to selected men to gain further experience in subordinate posts of control, and thereby receive under favourable conditions a first experience of responsibility. The progress of academic study is not interrupted for too long a period, and the close association between theory and practice throughout the whole of the institution maintains a lively interest in experimental and research work during academic studies, as conversely the study of materials and the nature of working them interests the men in the workshops. The course of training covers a period of five years, and training is offered in all branches of engineering. At the end of the course men graduate as holders of either the diploma or associateship of the college. Many of the major engineering institutions now recognise the training carried on at Loughborough and give exemption to men holding the diploma. It is very difficult to determine what is the distinctive mark of an engineer and what conditions should be attached to the right to use this title, and which is the best form of training, but, having in mind the requirements of the industry concerned, it is fair to assume that training, which offers academic instruction comparable with sister colleges and universities and at the same time meets the requirements of the industry concerned, is to be strongly recommended.

Yours faithfully,
H. SCHOFIELD,
M.B.E., Ph.D. (Lond.).

Loughborough, March 30, 1925.

GAS MASKS FOR PETROLEUM VAPOURS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the latter part of your article on "Gas Masks for Petroleum Vapours," which appeared on page 386 of your issue of March 27 you say: "The rubber bags for oxygen on the market up to the present have not proved impermeable to petroleum vapours. . . ." This is not correct. We have for years been supplying, as part of our "Proto" and other types of self-contained breathing apparatus, special rubber bags which are proof against these vapours, and, as a matter of fact, the American Bureau of Mines, whose recent report you quote, themselves made comparative tests about four years ago with the breathing bags of all types of apparatus (American, German, and British), including our own, and they reported in their Technical Paper No. 272, of 1921, that our material, "*alone of those in use, proved completely impervious to all gases.*" The writer of the later report, as referred to in your paper, was evidently unaware of his Bureau's own earlier report on the subject.

We have had far longer experience in the designing and manufacture of breathing apparatus than anybody else, and years ago we were fully alive to the need for special material to withstand petroleum vapours, and produced something which effectively met the case, and which actually passed the stringent tests set by the American Bureau of Mines in 1921.

We are, sir, your obedient servants,
SIEBE, GORMAN AND CO., LIMITED,
R. M. DAVIS, Director.

187, Westminster Road, S.E. 1, April 3, 1925.

TESTS OF THICK AEROFOILS.—Reports and Memoranda No. 928 (Ae. 150), recently issued, describes a routine wind-tunnel test on four thick aerofoils carried out by Messrs. F. B. Bradfield and A. S. Hartshorn, of the Royal Aircraft Establishment, Farnborough. The aerofoils tested were designated R.A.F. 30, 31, 32 and 33, and the theory of their design has been dealt with in R. & M. 946. R.A.F. 30 is a symmetrical section, having twice the thickness of the well-known R.A.F. 15 section, and the other sections tested have all been derived from the former. Lift, drag and centre of pressure were determined at VL = ·40 on models of 8-in. chord and 48-in. span, lift and drag also being measured at VL = 53·3. We notice that some of the sections give higher values of maximum lift than R.A.F. 15, but the minimum drag is also higher, and the maximum value of the ratio L/D is lower. It is understood that full-scale experiments will be made with sections R.A.F. 31 and 32. The report can be obtained from any of the branches of H.M. Stationery Office, price 6*d.* net.

FORESTRY IN THE EMPIRE.

THE visitor to the Dominions who is taken to arboreta and institutions for silviculture is liable to draw the conclusion that the Dominions do more in the way of studying and preserving forests than the Old Country, which passed a Forestry Act only in 1919. On the other hand, he sees magnificent felled timber rotting away in British Columbia and Australia, simply because transport is too expensive; and in reality the difficulties of distances, fires, insect pests and scarcity of population and of means of transport greatly handicap any active forest policy. In Canada, Mr. E. H. Finlayson, director of the Dominion Forest Service, says, in a paper on "Silviculture in Canada:" "We boast of our 80 or 85 per cent. public ownership of forest lands; but can it be said that the public lands are handled one whit better than are private timber lands?" The next paper, contributed to the same number of the December, 1924, issue of the Empire Forestry Journal (London: Imperial Institute; price 4*s.* net), a review of the report of the Royal Commission on Pulpwood, shows that Canada must cease to confine attention to the revenue-producing aspects of the forest resources. In 1918, some 360,000 cords of wood pulp were produced; in 1922, Canadian pulp mills used 2,912,000 cords of pulp wood, and further exported 1,500,000 tons of pulp wood (not of pulp). The 100 pulp mills employed 50,000 men in the mills and forests, 400,000,000 dollars were invested in the industry, and 80 per cent. of the pulp went to the United States and 17 per cent. to Great Britain.

In the British Empire, Mr. J. C. Corbin estimates in the same journal, the State forest area far exceeds that under other control, but 793,000,000 acres of other forest land remain practically unexploited and unprotected. In Germany, the home of scientific forestry, and other Continental countries, private ownership of forests has long since ceased to entitle anybody to cut down and clear at pleasure; tree-felling and re-afforestation have to go together. Indian forests, threatened with extinction 70 years ago, have, owing to rational legislation, once more become a national asset of great value. In the United States, President Coolidge stated last winter in addressing a conference, that most of the cutting had been done, not in the last 300 years, but in the last 75 years. With an annual drain of 25 billion cub. ft. of timber from 725 billion cub. ft. left, and an annual growth of 6 billion cub. ft., they were not far from timber exhaustion. These matters call for serious consideration. We should add that the journal quoted contains many other contributions of interest, notably one by Mr. C. Marshall Taylor on "Wood Preservation."

THE RIVER TYNE OFFICIAL HANDBOOK.—An interesting account of the development at the River Tyne, from the middle of the nineteenth century to the present day, is included in "The River Tyne Official Handbook," just published by Messrs. Andrew Reid and Co., Limited, of Akenside-hill, Newcastle, for the Tyne Improvement Commission. The book, which is issued with the object of providing full information regarding the commercial and constructive facilities available at the many ports on the river, is extensively illustrated and contains a number of maps. One shows, on a scale of 2 in. to a mile, the river and surrounding territory from the North Sea to Newburn. The work supplies particulars regarding the important coaling and oil-fuelling and discharging equipment built at the docks, while the various shipbuilding yards are described in detail. General statistics on trade and a comprehensive list of foreign and coastwise steamship services materially add to the value of this useful publication.

SMOKE ABATEMENT CONFERENCE.—The report of the Smoke Abatement Conference held in Manchester in November of last year is now to hand. The papers read at the meetings embraced all phases of the complex problem of smoke abatement. While some dealt with actual conditions prevailing and the injurious effect of soot suspended in the atmosphere upon the health and well-being of the community, others aimed at devising means of combating the evil by reducing the wastage of fuel due to imperfect combustion. Several able papers dealt with the subject from the mechanical engineer's point of view, among them being "The Complete Gasification of Coal," by Mr. T. R. Wollaston, dealing with modern producer practice; "Powdered Fuel," by Dr. J. T. Dunn; and "Boiler Room Economics," by Mr. J. T. Hodgson. Low temperature carbonisation and smokeless fuel were subjects discussed by Messrs. R. Maclaurin, H. Nielsen, and others. The advantages of using gas, coke, and electricity, both from the point of view of economy and of cleanliness, were well demonstrated in papers by Messrs. F. W. Goodenough, E. W. L. Nicol, J. Frith and J. W. Beauchamp. Professor Miles Walker spoke on the subject of the power which might be derived from tides and falling rain. An important conclusion arrived at was that, whereas industrial concerns were turning their attention more and more to the solution of the problems raised, enough consideration had not been given to household fires which were largely responsible for existing air pollution.

LABOUR NOTES.

WHETHER the engineering trade unions are to continue to press the employers for an unconditional offer on the wages question will be decided by a conference of executive representatives which has been called for April 23 in London. At an earlier meeting of the same kind, the representatives of the unions were extricated from what appeared to be a difficult position by the intervention of the Ministry of Labour. They had attended, it was understood, with authority to press for an unconditional offer, which meant, in view of the known attitude of the employers, a strike ballot. In the opinion of the employers the question of a wages increase and the question of such an easing of working conditions as will reduce costs hang together. The effect of the Ministry's intervention was the appointment of a small joint committee to resume the negotiations. This smaller body duly met, but, unhappily, could make no headway towards a settlement, largely because the men's representatives took the view that they had no authority to discuss anything but an unconditional offer on the wages question. They are now reporting to a full conference of executive representatives and, presumably, asking for fresh instructions.

On the following day, a conference of executive representatives of the shipyard trade unions will be held in London for the purpose of deciding whether to accept or to reject the proposal of the Shipbuilding Employers' Federation to set up a joint committee of investigation into the economic position of the shipbuilding industry, its capacity to cope with foreign competition and its costs, both direct and indirect. Hope is general that the unions will agree to the proposal, and that the investigation will be begun as soon as possible.

How shipbuilding costs within the industry could be materially reduced was indicated by Mr. James Lithgow, of Port Glasgow, in the extremely able review of the economic position which he gave on Wednesday last week to the Commercial Committee of the House of Commons. In addition to the substitution of payment by results for time work, there was another direction, he said, in which without loss, either of dignity or of earnings, considerable economy could be effected in the running of shipyards. It had to be remembered that the British shipbuilding industry was the gradual growth of generations and that, in course of time, labour had organised itself in sectional trades to a degree that was not known in the younger shipbuilding countries. Each section regarded its rights and privileges with a jealousy that was almost incredible. It might well be that segregation of labour into trades and into their own craft organisations induced a pride of craft which reacted favourably on the skill and competence of workmen; but, particularly in these latter days, when machinery had so much displaced the old hand crafts, the segregation of workmen into small trade units had, undoubtedly, added enormously to the cost of ship construction. He did not suggest for a moment that the essentials of individual trades should be carelessly dealt with, but there were many operations which were not fundamental to any one trade and could be carried out by any skilled man or, even in some cases, by a semi-skilled man. In that direction, Mr. Lithgow suggested, a very considerable saving could be effected within the industry.

If, he went on to say, all the old privileges were retained and the old segregation continued—there were over 30 trade unions operating in shipyards—the installation of machinery would only add, as many shipbuilders had discovered, to the cost of production. Employers and employees must address their minds to the adaptation of their organisation to the proper and efficient use of labour-aiding machines and facilities and have very much greater freedom in the mobility of labour. For the last two years shipbuilding employers had been driven by the hard necessity of unprofitable orders to revise their managements and cut down on-cost charges to the lowest point, and he was firmly of the belief that if labour now showed itself ready to adapt itself to the new circumstances in which the industry found itself, a substantial saving in costs could be achieved. By avoiding wasteful disputes and irritating and expensive stoppages of work they could also make a considerable saving.

But, Mr. Lithgow declared, even if all the savings that could be effected inside shipyards were affected, the remedy for unemployment in shipbuilding would still be to seek. It could not possibly be found within the industry. Shipbuilding was a constructional industry dealing with expensive and, some of them, elaborate integral parts, and was a customer for a great many other industries. The costs in coal, timber, steel and a great variety of engineering, as well as marine engineering material had, undoubtedly, a considerable effect on the total cost of a ship. He did not think he was exaggerating when he said that in shipbuilding costs had been reduced to a greater degree than they had been reduced in any other of the sections of industry, and to an infinitely greater degree than the public services, whether municipal or transport, whose charges also it had to bear both directly and indirectly. Shipbuilding was still, as it was pre-war, a strong, well-organised and virile industry, with pre-eminent technical skill, and if the problems that faced it were soluble within the industry itself there would be no need to make an outside appeal. But he could not state his belief too firmly that unless the whole public conscience was awakened to the broader and cumulative handicaps under which it, in common with all British exporting industries, was working to-day there could be no hope of restoring the shipbuilding industry to its old position of supremacy. Even when each individual industry had done all that it could something more remained.

Writing of the conditions in Leningrad, the Moscow correspondent of the *Soviet Union Review*—which is the official organ of the Trade Delegation of the U.S.S.R. in London—states that from numerous conversations he has had with prominent workers, he gathers that the shortage of working capital is still a very real problem, and the only obstacle standing in the way of a more rapid development of industrial output.

In his latest *Bulletin*, the Industrial Commissioner of New York State reports that there were several large changes in employment in the metal industries in January, but increases in some lines of manufacture were off-set by serious decreases in two or three others. The steel mills of the State continued to extend operations, and it is estimated that 900 men were taken on. In December there was an addition to working forces of 1,400 men. A striking feature of the past few months has been the rapid advance of steel to the position it occupied at the beginning of 1924. This has taken place while some of the industries which absorb the products of the mills have lagged in the movement towards recovery. The earnings of the men are approximately the same as a year ago. Most of the brass and copper mills reported small gains.

While several automobile factories which were high throughout the fall continued to reduce forces, others started upward. The turn with the approaching spring season was responsible for an improvement in some of the hardware and stamped ware factories manufacturing for the automobile industry. Heating apparatus shops re-employed more than half of the men released in November and December and earnings rose over 4 dols. On the other hand, stove manufacturers curtailed forces further. Employment in this industry is lower than it has been since the heavy residential construction of the past two years began.

There was a sharp contraction in railroad equipment shops which resulted in a lay-off of almost 2,000 men in the representative factories. Earnings averaged the same as in December. While the other metal industries reported much smaller changes, these were important as indicating the present tendency in manufacturing. Electrical machinery, office equipment and measuring instruments were about the same as in December. These factories have, on the whole, been running on a somewhat reduced scale since September. Foundries and other machine shops showed a small net gain in employment, but little increase in pay rolls. Earnings were lower in cutlery plants, but a few more workers were employed. Seasonal factors explained a large increase in agricultural implements.

Sir John Dewrance, president of the Engineering and Allied Employers' National Federation, gave evidence before the Committee on Industry and Trade on Wednesday last week. Mr. D. A. Bremner, director of the British Engineers' Association, had previously shown from trade statistics that the production of the engineering industry for export was on an increasingly unprofitable basis. That view was supported, as regards production as a whole, by Sir John, who produced the results of the Federation's investigation into production costs as a percentage of turnover for the financial years ending in 1923 and 1924. This investigation, the Federation claimed, showed that, while the latter year had seen an increase in the volume of production over the former, it had been of a less remunerative character. The credit balance left over after discharging cost of materials, wages, general charges and administration, which was only 2·8 per cent. in 1923, had fallen to 1·4 per cent. in 1924. Sir John proceeded to deal with those aspects of labour conditions which were responsible for this serious tendency. A comparison of wages, hours of work and working conditions in this country and in foreign competitive countries was made, indicating the handicaps under which British manufacturers labour from these causes as compared with foreign competitors, both in the home and foreign markets. With regard to the efficiency of labour, it was pointed out that while in quality of workmanship the British engineer is generally recognised to be first in the world, quality alone without relation to cost is no longer sufficient to secure orders. With regard to efficiency of management, plant and equipment, it was shown that these had never been higher than at the present time in the British engineering industry.

As far as labour matters were concerned, the crux of the question was, Sir John Dewrance said, that the workpeople should realise the necessity for giving their best output, and that they should not be held back from doing so either by individual inclination or the regulations of organised labour. The Federation was doing all it could to impress this point of view upon the workpeople and their representatives. With regard to industrial disputes, the Federation believed that the Provisions for Avoiding Disputes, which they had evolved in concert with the leaders of the trade unions and which had been satisfactorily worked for twenty-eight years, were the best methods which had hitherto been devised for the purpose. They did not, therefore, support any suggestion of State interference in industrial relations, but felt that the solution of the problems now confronting the industry lay in the closer co-operation of those engaged in the industry.

The Ministry of Labour states that on March 30, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,194,300—923,900 men, 31,400 boys, 210,300 women, and 28,700 girls. On March 23, 1925, the number was 1,201,315—926,658 men, 32,453 boys, 213,288 women, and 28,916 girls—and on March 31, 1924, it was 1,058,273—783,431 men, 31,700 boys, 211,294 women, and 31,848 girls.

The South Wales Miners' Federation has now formulated its demands for a revision of the existing general wage agreement and forwarded them to the Miners' Federation of Great Britain for submission to the delegate conference which is to be called for the purpose of framing the final proposals. The South Wales decision was embodied in the following resolution, which was passed unanimously:—"That the minimum rates of wages payable shall be those obtaining in 1914 *plus* the increased cost of living as published by the Board of Trade from time to time." The South Wales delegation at the National Conference is to be instructed to support proposals made from other districts in the direction of ensuring the following reforms: (1) That the 2*s.* a day given under the Sankey Award for the general raising of the standard of living of the miners should be reinstated; (2) That the workmen employed by night should have a general week of five nights, and be paid at the rate of a turn and one-fifth for each night worked; (3) That the Conference press that membership of the Miners' Federation should be made a condition of employment at the collieries; (4) That miners be guaranteed a weekly wage, with two weeks' holiday with pay every year.

At a meeting on Saturday of the Administrative Council of the International Labour Office, the French Government representative proposed that the question of the eight-hour day in the merchant service should be included in the agenda of the 1926 International Labour Conference. He recalled that at the meeting of the Maritime Commission at San Sebastian in September last year representatives of the seamen were unanimous in desiring that the question of hours of work should be dealt with by the 1926 conference. The proposal received the support of several Governments, particularly the Italian Government, while the entire Labour group voted in its favour. The British, German, Japanese, Belgian, Canadian, and Finnish Governments, however, were opposed, and after the vote had been taken, which resulted in 12 for and 12 against, the proposal fell through.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—In the year 1880 the first volume of the Transactions of the American Society of Mechanical Engineers appeared, and since then the only general indexes available to papers read before the society have been those published in vols. v, x, xv and xxvii of the Transactions. Until the present time some 46 volumes in all have been issued and a Transactions Index has now been completed which covers the contributions and discussions given to the society from its inauguration until the end of 1923, when vol. xlv was published. Items have been fully cross-referenced and grouped alphabetically under author's names, the latter appearing in bold type. Memorial notices conclude the work. All enquiries regarding this index should be addressed to the offices of the society at 29, West 39th-street, New York.

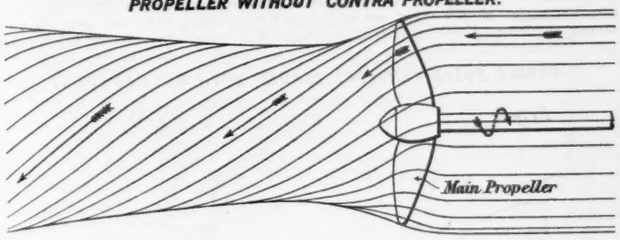
INCREASING THE EFFICIENCY OF THE SCREW PROPELLER.*

By WALTER POLLOCK.

IT is well known that the water flowing from a ship's propeller moves tangentially and axially as in the upper view in Fig. 1. The object of the "Star" contra-propeller is to convert the tangential flow into an axial flow and so increase the propeller efficiency. This is effected by means of guide blades, which may be fixed either forward or aft of the propeller or both. These blades are so formed as to divert the flow of water as it leaves the propeller blades in a direction more or less perpendicular to the face of the blade, into a direction parallel to the line of the ship's course as shown in the lower view of Fig. 1. If, however, the contra-propeller is fitted forward of the main propeller, the water flowing through its blades has its direction changed before it reaches the main propeller, as shown in Fig. 2. The blades are so curved that just sufficient change of direction is given to prepare for and to counteract the rotary motion ordinarily given to the water by the main propeller. Since the one change of direction is just neutralised by the other, the water is thrown off the main propeller blade in a direction parallel to the course of the ship. That the object aimed at has been achieved has now been proved, not only in experimental tank tests but in ships in actual service. The tank tests have been carried out in the Hamburg tank, which allows models up to 40 ft. in length to be run at speeds up to 33 ft. per second, while apparatus provided allows propellers up to 24 in. diameter to be tested, which adds greatly to the value of the results as compared with the 8 in., which was the original maximum diameter. The propellers are made from bronze or a special white metal finished to their correct form by special grade moulding machines, and afterwards checked by means of accurate measuring instruments. The tank tests with the large propeller are made without a model of the hull. In the case of twin-screw ships of large size, however, it is advisable to make tank tests both with and without the hull in order to ascertain the effect of the stream lines caused by the stern-frame brackets and boss plating, and so enable the best form and curvature of the contra-propeller blades to be designed.

The practical results obtained in actual service from a few of the 120 ships which have now been fitted with this device are given in Appendix I, and these go to show that there is a very definite advantage to be

Fig. 1. ACTION DIAGRAM A.
PROPELLER WITHOUT CONTRA PROPELLER.



PROPELLER WITH CONTRA PROPELLER.

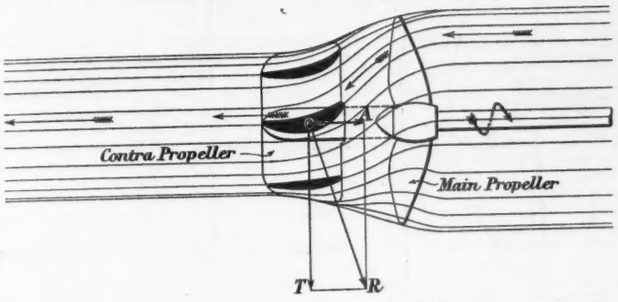
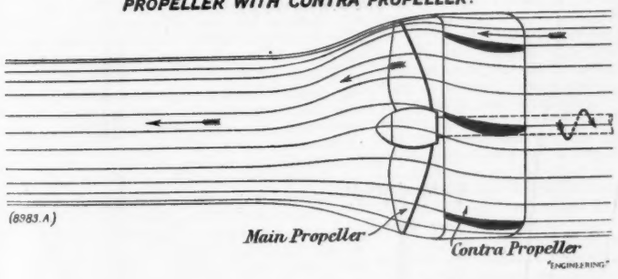


Fig. 2. ACTION DIAGRAM B.
PROPELLER WITH CONTRA PROPELLER.



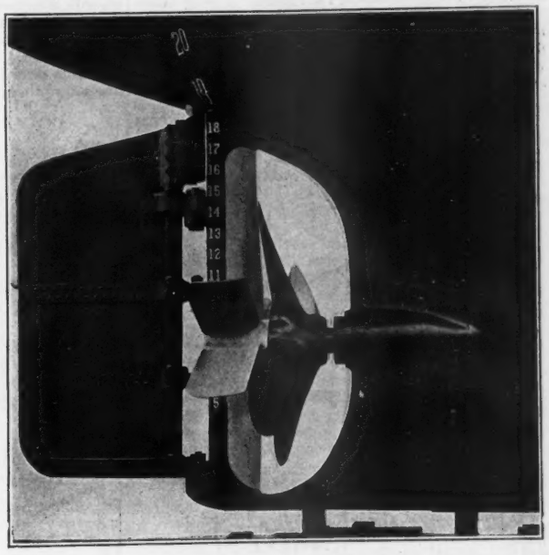


FIG. 4. CONTRA-PROPELLER ON M.S. "SILVERLARCH."

Fig. 5. TYPE IA.

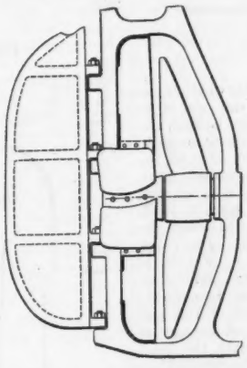


Fig. 5A. TYPE IIA.

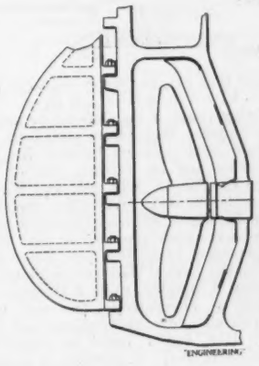


Fig. 7. TYPE IIIB.

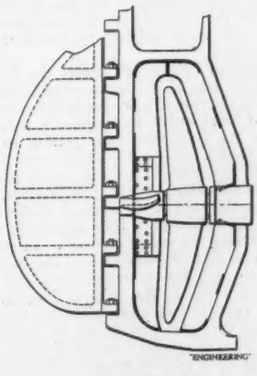
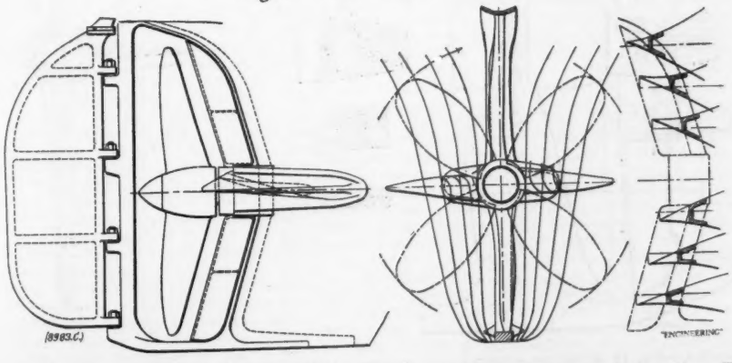


Fig. 6. TYPE IIB.



* Paper read before the Institution of Naval Architects, London, on Thursday, April 2, 1925. Abridged.

gained. Hitherto, however, the variations among different types of ships in coefficient of displacement, and in the formation of the stern-frame and aperture for any given tonnage, have made it difficult to ensure a uniform gain in efficiency, but recent tank experiments have furnished information which will enable that difficulty to be overcome in the future.

The Star contra-propeller can be built in a large number of forms, some of which are shown in Figs. 5, 6 and 7, and a great deal of the success of an application will depend upon the correct selection of the type to be adopted, which must vary according to whether the vessel is an existing one or one to be built, whether she is to have twin screws, and so on. In the case of an existing vessel, if the stern-frame aperture is wide and the propeller blades have very little set-back so as to give a good clearance between the after edge of the propeller and the forward side of the rudder post, type IB, Fig. 11, with only four blades, will, in most cases, be the best. Where the available space is small, type IA, Fig. 5, will be preferable in order to obtain the increased surface provided by that design. For a new single-screw vessel the type illustrated by Fig. 9, in which the vertical blades are solid with the rudder post, should be adopted, while if the stern post be suitably forged or, alternatively, the stern plates of the hull carried aft and suitably shaped, all the advantages of type IIIB, Fig. 7, could be obtained with the least increase in cost. If, however, it should be decided not to fit the Star in the first instance, provision could be made for so doing subsequently by adopting the form of stern frame illustrated in Fig. 8. In the case of a new vessel of the single-screw mail/passenger type with fine lines, the most satisfactory selection would be type IIB, Fig. 6.

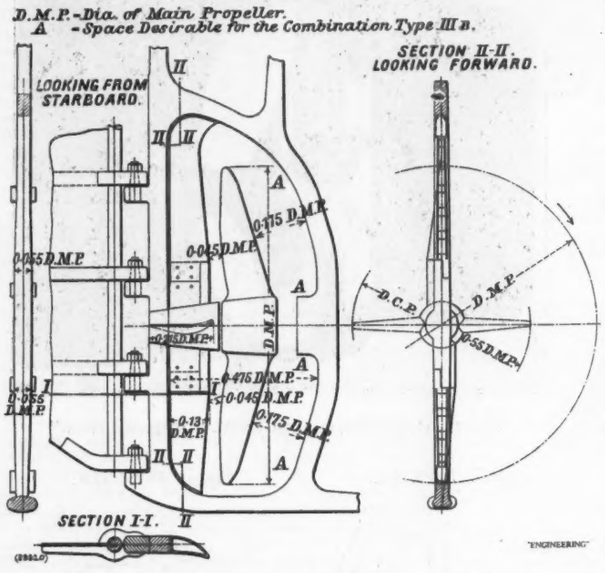
With existing twin-screw vessels the fin or blade outside of the boss-plate means an additional attachment, but in the case of new vessels it it comparatively simple and inexpensive to shape the propeller-shaft bracket or the stern-tube boss plating to form the necessary blades, and in the latter case the plating may also be extended to form the outer blade with a minimum of difficulty. In the type illustrated in Fig. 9, designed by the author, the vertical blades are forged solid with the rudder-post, thus dispensing with welding and reducing the weight and cost. In this arrangement the fore and aft dimension of the rudder-post is increased to give the necessary area and form the required curvature in the original forging. At first this may appear somewhat difficult, but on close examination the total cost would be found to be no more than that of special forgings of stems and other parts for the same relative weight. If sufficient width could be obtained it might prove possible to adopt these vertical blades alone and dispense entirely with side blades. An interesting proposal is that of Mr. E. W. Harvey, who suggests a casting to ship over the rudder-post (see Fig. 10); the object is to do away with welding entirely and its concomitant cost and expenditure of time. This method of fitting could only be carried out if the rudder-post was a good forging and in line with the axis of the main propeller, otherwise it would be necessary to make a special casting which would be comparatively costly and heavy.

In general, the dimensions of a contra-propeller are governed by the dimensions of the main propeller, the stern-frame aperture and the indicated horse-power, which must vary considerably with the type of ship and the particular views of its designer. For this reason, it is impossible to standardise the device as regards dimensions and weight. Each case must be dealt with independently except where the vessel under consideration is a sister-ship to one which is already fitted. In this case it might be possible to use the same drawings for the second vessel, making the necessary alterations in the process of fitting. The diameter of the contra-propeller may be taken to be approximately 55 per cent. of the diameter of the main propeller; Fig. 11 shows the approximate dimensions of type IB.

One of the chief objections which may be raised to the contra-propeller is the weight, and it is quite true that no shipowner would fit a device weighing several tons, as it may do in a large vessel, unless he could see some substantial advantage. It is therefore desirable to reduce the weight as much as possible so that the very slight decrease of the deadweight cargo capacity may be reduced to a minimum, and also that the stresses on the stern-frame and stern plating may not become excessive. The weight is governed by two factors—the stern-frame aperture and the indicated horse-power. It will be observed that in several types the vertical blades run the full height of the stern-frame aperture but this vertical height varies considerably in ships of the same horse-power. The clearance between the after edge of the main propeller and the forward edge of the rudder-post also varies, and this again affects the weight. Fig. 12 has been prepared to give the average weights, based on vessels of different types which have already been fitted with this device. It is also obvious that, besides the weight to be carried, the contra-propeller will offer additional resistance, though this is not so great as would appear at first sight, because in most types the leading edges are very fine and the trailing edges well rounded; whereas in an ordinary stern-frame the forward surface of the rudder-post is flat, and in a 10,000-ton ship is often 8 in. wide and 21 ft. high, which is equivalent to a flat surface of 14 sq. ft., while the after-side of the post has a flat surface of 12 sq. ft. The relative resistances do not appear to have been ascertained, but the author intends to investigate this important question by means of tank tests on large models.

Some of the early forms of type IA were designed and constructed after careful calculations had been made of the various stresses due to the water leaving the

Fig. 8. AN IDEAL STERN FRAME.



FORGED SOLID VERTICAL BLADES WITH RUDDER-POST.

Fig. 9.

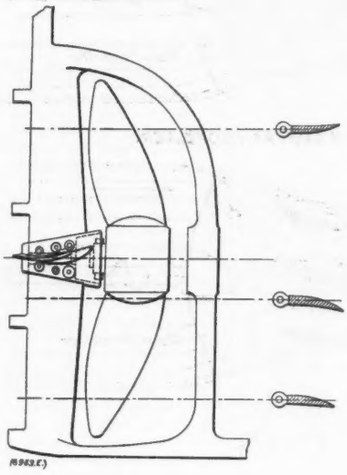


Fig. 10.

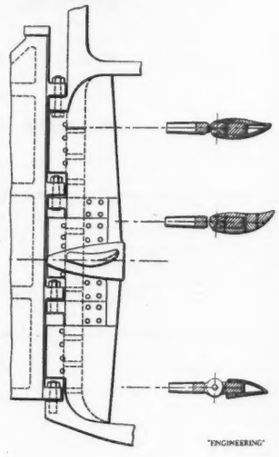
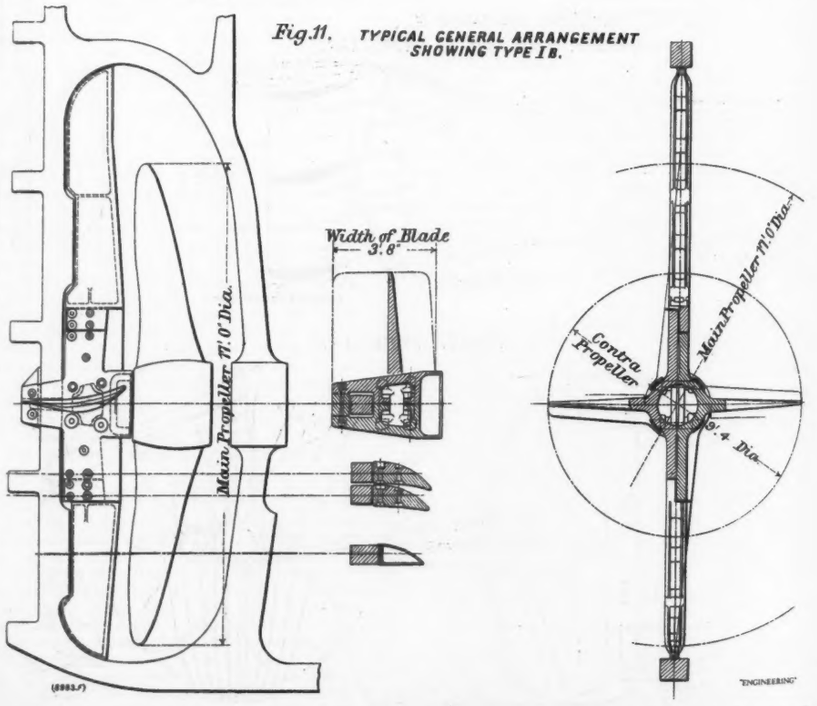
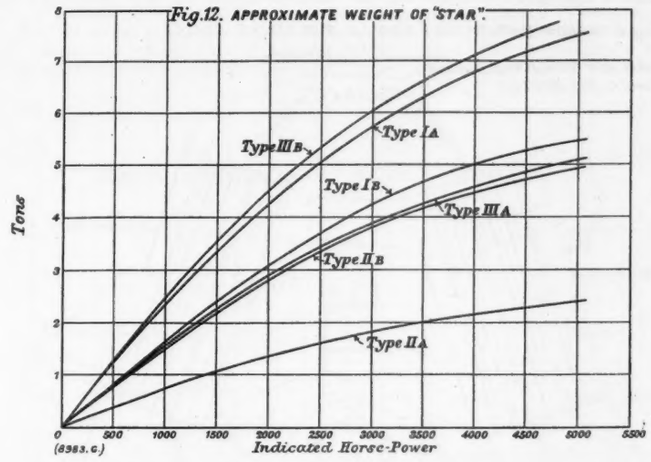


Fig. 11. TYPICAL GENERAL ARRANGEMENT SHOWING TYPE IB.



THE EFFICIENCY OF THE SCREW PROPELLER.



main propeller, and these showed that the root section of the side blades was amply strong in smooth water. In several cases, however, they proved to be too weak to stand the pressures in a heavy sea, especially those blades with a concave surface on the under-side, and several were found broken. Whilst the calculations were being overhauled and the root section of the blades increased, tank tests proved that by slightly increasing the area one blade on each side was almost as efficient as two. This reduction in the number of blades enabled the single blade to be made thicker and stronger and partially solved the problem of weight.

The natural evolution in that direction will be found in the later designs—for instance, type IIA, Fig. 5A, consisting of vertical blades only, forward of the main propeller, is of the lightest possible construction, and when incorporated with the hull plating has little or no additional weight compared with the ordinary ship construction without a contra-propeller. In the case of twin-screw vessels with plated bosses to carry the tail-shafts, a contra-propeller can be formed very easily by extending the plates to form the curved vanes or blades necessary to deflect the flow of water to the propellers. This only slightly increases the weight.

In new single-screw vessels of large tonnage, designed and built without stern-frames and with overhanging rudders, a very light and economical arrangement can be adopted by curving the ship's plating as shown in Fig. 6, with a suitable form of stern-post. The advantage of this type is that it dispenses entirely with separate castings or forgings and so greatly reduces the weight, and also the cost.

The material to be used in the construction is governed to some extent by that to which the device is to be attached. For ordinary stern-frames the vertical blades are usually made of cast steel to facilitate welding to the rudder-post, the side blades being made of cast iron hollowed at the boss to house the main propeller nut, and designed so as to retain the continuity of strength of the vertical blades and strengthen the rudder-post as a whole. It is generally recognised that electric welding on a large scale, as is necessary in several types, is a disadvantage; it takes a considerable time to carry out the work if done to an existing vessel, and is expensive, both as regards the cost of welding and the rent of the dry dock. The design and method of attachment as at present adopted is unusual, and the amount of welding required is, in the author's opinion, excessive. In the case of a vessel of 8,500 tons and 2,250 brake horse-power, the vertical blades, which have a total depth of 16 ft. 6 in., were welded on both sides of the rudder-post, and this called for electric welding to the amount of 336 cub. in. This could undoubtedly be reduced with satisfactory results both as to weight and cost. If the sectional area were reduced, continuous welding could be retained, otherwise "spot welding" might be adopted. With a solid rudder-post of the design suggested in Fig. 9, the Classification Societies would, no doubt, greatly reduce the sectional area of the rudder-post proper, in view of the increase of sectional area due to that portion formed by the vertical blades. This design could be adopted with or without one or more blades on each side to suit the requirements necessitated by the shape of the vessel and the area of the stern-frame aperture. At present the Star is not very well known to the classification societies in this country.

(To be continued.)

THE RUSSIAN METALLURGICAL INDUSTRIES.

THE members of the Trade Union Delegation, who took part in a well-staged visit to Russia in November last, have since their return to this country been at pains to spread the idea that the results of the revolution are represented by a new State, very powerful and likely to be very prosperous.

One fact, however, cannot be ignored by those who give even the most superficial consideration to Russian affairs, and that fact alone is sufficient to show that the country is far from being prosperous. Whereas Russia, before the war, not only fully supplied her own needs in cereals, but also exported wheat in large quantities to other nations, she is now compelled to purchase that essential commodity in foreign markets. The same remark applies to other agricultural products. The consequence of this neglect of her agriculture, both upon her own population and that of other countries, is evident and needs no comment. Russia's wheat production in 1913, leaving out Poland and Finland, was 67,200,000 metrical tons; it had fallen to 25,448,000 tons in the twelve months from October, 1922, to September, 1923; while the production for the twelve months ending September, 1924, was 32,656,000 tons, or less than half the pre-war figure. Taking another staple article of food, we find that the potato crop for the same territory and for the same periods was 29,600,000 tons, 19,328,000 tons, and 15,856,000 tons. Figures such as these afford an all too clear indication of the unsound condition of the country.

At the moment, however, we are not concerned so much with Russia's agriculture, bad as this must be, as with her mineral resources, and her iron and steel industries. In regard to mineral wealth she occupies a most enviable position. Her probable coal resources, taking both European and Asiatic Russia, have been estimated at over 460,000 million tons, of which close upon 40,000 million tons are anthracite. In the Donetz basin alone, in South Russia, it is estimated that there is about 60,000 million tons of excellent coking coal. The great majority of the coal seams are said to be comparatively very easy to work, being at relatively small depths, and many being thick seams. The principal iron-ore district is that of Krivoi Rog, which was stated some time ago to contain much over 200,000,000 tons of ore up to a depth of about 700 ft. Ore exists also in large amounts in other parts of the country. The managnese ore deposits are said to contain close upon 50,000,000 tons.

In 1913 the coal output of Russia, omitting Poland, was 28,400,000 tons; the corresponding figure for the twelve months down to September, 1923, was 10,300,000 tons, and for the twelve months down to September, 1924, the output was 14,700,000 tons. In 1916, previous to the revolution, the corresponding coal output had reached a total of 33,700,000 tons. By far the greater proportion of the coal output proceeded from the Donetz basin. As will be seen there has been an improvement in the output between the 1923 period and that of 1924, but the advantage of this increase has been largely lost owing to the great difficulty experienced in delivering the coal. The stocks at the pit mouths remain very large and means are, it is said, being taken to restrict the output for the twelve months down to September of the current year. Coal consumption at the collieries is put down at 16·3 per cent., or about double the pre-war figure. The cost price of the coal at the pit mouth is not made public.

The quantity of coke made in the Donetz basin in 1913 was 4,400,000 tons; about an equal quantity was made there in 1916; the quantity made in the twelve months down to September, 1924 was 1,810,000 tons.

The output of iron ore in 1913, exclusive of Poland, was 10,200,000 tons, of which the greater part was mined in the Krivoi Rog district. The figures for the twelve months down to September, 1923 and to September, 1924, were, respectively, 360,000 tons and 816,000 tons. The corresponding figures for the manganese output were 1,240,000 tons, 210,000 tons and 410,000 tons.

Russia's pig-iron production in 1913, leaving out Poland and Finland, reached a total of 4,110,000 tons, in which amount South Russia figured for as much as 3,000,000 tons in round numbers. Russia thus came fifth in rank after the United States, Germany, the United Kingdom and France, the pig-iron production of the latter country having been 5,300,000 tons. From 4,110,000 tons in 1913, Russian production fell to 300,000 tons in the year ending September, 1923, but increased to 640,000 tons in that ending September, 1924. In these two latter figures, South Russia figured for 110,000 tons and 290,000 tons respectively.

Marked progress had been achieved in the Russian open-hearth steel industry, as is evidenced by the following figures, which apply to the country as it formerly existed, including Poland and Finland. The total steel production in 1904 was 2,700,000 tons, an amount which increased to 5,000,000 tons in 1913, being somewhat above the steel production in France in that same year. The open-hearth steel production in 1913, leaving out Poland and Finland, was 4,210,000 tons (in which South Russia was responsible for 2,700,000 tons); the corresponding figures for the twelve months down to September, 1923, and to September, 1924, were, respectively, 583,000 tons (South Russia, 188,000 tons) and 972,000 tons (South Russia, 296,000 tons).

Equally striking figures pointing to heavy decreases in production since 1913 could be given in the matter of rolled iron and steel material.

Naptha also shows a great falling off in output; the figure for 1913 was 9,109,000 tons; it rose to 9,634,000 tons in 1916. The output for the year closing September, 1923, was 5,085,000 tons, and for that ending September, 1924, 5,773,000 tons.

As will be gathered from the above figures, several of which have been taken from an article in *Revue de Métallurgie* by General Martchenko, who has kindly supplied us with supplementary data, the Russian iron and steel industries, like her agriculture and her mineral oil output, have declined heavily since the present Russian Government has been in power. A decree dated August, 1921, placed the coal, iron ore and metal industries of the country under the sole jurisdiction of the Government. The most important, best equipped and most favourably situated installations in each branch of the heavy iron and steel industries had either to be worked by the State or be grouped together under the supervision of State Boards. Hardly any opening was left for private enterprise and any attempt at working made by a private concern was sure ultimately to end in failure. That State ownership has likewise failed must be patent to the most casual observer.

The figures we give above indicate an increase in output and production in the twelve months ending September, 1924, compared with those for the preceding twelve months ending September, 1923. These two sets of figures, however, should not be considered alone, but in conjunction with facts relating to the means of transport of the country. These, we are informed, are now in a deplorable condition. On the Volga there are numbers of boats which have been abandoned and are now unserviceable. The quays on the different water routes are no longer lighted. Railway lines, such as that connecting Moscow with the Oural and other districts, are practically without traffic. The sleepers on many tracks have greatly deteriorated and need replacing, whilst the viaducts are said not to be capable of bearing one-quarter of the live-load for which they were built in the first place. On an important line near Moscow there were ten derailments in as many days last January, and rolling-stock debris, we are told, is still to be seen on the line.

The iron and steel works have been starved of fuel notwithstanding the richness of the country's coal-fields. The lack of coke has been, of course, one of the contributory causes responsible for the heavy decline in pig-iron production compared with 1913. In some instances furnaces which directly adjoin collieries could only be maintained in blast on a reduced output with coke sparingly supplied to them in the face of great transport difficulties from collieries located at a distance. The reserve stocks of iron ore are stated to be

now practically exhausted. The iron ore output per man employed is quoted at one-third the figure which obtained in 1913, notwithstanding the fact that work is now concentrated upon the iron mines which are the easiest to work. An article published in a Russian journal of economics has advocated, amongst other measures for facilitating the manufacture of open-hearth steel, the prohibition of the use of more than from 40 to 45 per cent. of pig-iron and a correspondingly increased delivery of scrap to the open-hearth furnace plant.

Cost prices, as we intimate above in regard to coal, are difficult to arrive at compared with the prices which ruled in 1913, but all the information we have received points to the fact that the Russian industries now work at a heavy loss, and, fortunately in the circumstances, they are not able to maintain the figures of output which have been provided for in the programmes repeatedly drawn up by the Government.

The present rulers of Russia appear to have brought something akin to ruin to agriculture and the other industries of their country. It is curious to note that the insignia which appears on their official publications shows a hand-hammer and a reaping-hook. Both would seem to have greatly fallen out of use since the revolution.

INTERNAL-COMBUSTION AND STEAM ENGINES FOR HIGH-SPEED PASSENGER VESSELS.*

By SIR JOHN BILES, K.C.I.E., LL.D., D.Sc.

(*Concluded from page* 417.)

THE weight of fuel and feed water will vary with the distance between fuelling ports. Table II (page 416 *ante*) gives these items for different types of machinery, and for two distances, 6,460 miles and 3,230 miles. It will be seen that for the longer distance the Diesel and the high-pressure turbine (or H.P.T.) type are tending towards the same total weight, while the present turbine type is about 50 per cent. more, the ratios being 1, 1·5 and 0·94. For the shorter distance the ratio is 1, 1·28 and 0·81 for the (*a*), (*b*) and (*c*) types respectively. The mean displacement on the voyage will be affected by the consumption of fuel, &c., to the extent shown in Table II. The corresponding ratios of the mean weight for the two distances are 1, 1·28 and 0·81 for the 6,460 miles' run, and 1, 1·14 and 0·72 respectively for the 3,230 miles. No account is taken of the effect upon stability of the ship by the use of water ballast to compensate for the reduction of these weights. The question is too complex to admit of a simple solution, but it may be safely assumed that there is sufficient stability in all cases to make the mean variation in water ballast of minor importance. A comparison is shown between an existing Diesel ship and one having about the same weight of machinery fuel and feed water.

Table III gives estimates of capital charges and cost of fuel for the same various types of ships and for various distances run per annum. The costs of machinery are for the whole installation of boilers, engines, and auxiliaries as completed in the ships. In the case of 20-knot vessels, the Diesel type of engine costs 13,000*l.* per year more to run than the steam, while at 17 knots the cost per annum of the Diesel is 7,000*l.* more than that for the steam. But the cost of running the steam vessel at 18 knots is only 8,000*l.* per year more than the Diesel at 17 knots. Some investigations have been made for higher powers which may be of interest. In the case of the 20-knot vessel with the (*c*) type of machinery, it will be seen that a gain of 1,052 tons of weight is available in the 3,230-mile voyage. Transforming this weight into machinery fuel and make-up feed, it is possible to increase the shaft horse-power to 40,000 and the sea speed to 22 knots. It is to be remarked that the weight of turbine machinery per shaft horse-power tends to decrease with increase of power. An estimate of an installation of such machinery for 55,000 h.p. in a 24-knot ship shows that the weight is about 3,600 tons, which is one-third more than that in a 20-knot ship, while the power is more than double. It is not easy to see how a Diesel installation of this power could be applied to a ship at the present time, and its weight would probably be about 8,000 tons.

It is, however, in the region of lower powers than those dealt with that the interest of the large majority of shipowners is most centred. It cannot be said that the turbine has displaced the reciprocating engine in this region. The reduction in weight of the (*c*) installation is due in part to the use of high efficiency water-tube boilers and oil fuel, which require higher skill in their handling than the ordinary merchant-ship boiler, coal-fired. But a similar consideration has to be kept in view in the adoption of the Diesel engine in the ordinary type of tramp steamers. Both types involve the training of more highly skilled engine-room staffs, which time only can create. In the case of cross-Channel steamers of high speed the turbine has completely displaced the reciprocating engine. In this case the weight and first cost of the installation are the dominating considerations, for the distances run are short and the amount of fuel carried is comparatively much smaller than in vessels trading overseas. It is of interest to examine such a case to see if steam is likely to be displaced by the Diesel engine. The case of an installation for a 20-knot vessel of 5,200 h.p. has been chosen. Table IV gives comparative figures for a twin-screw vessel.

Fig. 6. YARROW WATER-TUBE 500-LB. PRESSURE BOILER.

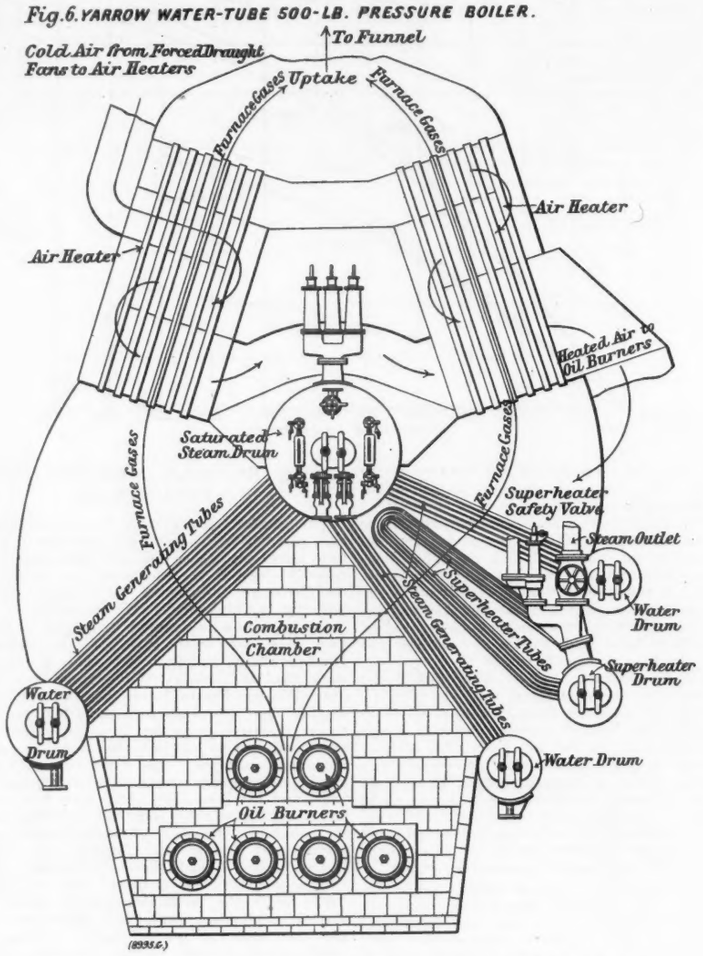


TABLE III.—ANNUAL COSTS FOR VOYAGE OF 120,000 MILES.

	(*a*) Diesel.	(*b*) Steam.	(*c*) H.P.T.	(*a*) Diesel.	(*c*) H.P.T.	(*c*) H.P.T.
S.H.P.	27,000	28,000	27,000	13,500	13,500	16,900
Cost of machinery	460,000*l.*	380,000*l.*	333,000*l.*	240,000*l.*	175,000*l.*	210,000*l.*
Interest, depreciation, insurance, and maintenance per year	85,100*l.*	70,390*l.*	61,605*l.*	44,400*l.*	32,380*l.*	38,850*l.*
Distance steamed per year, miles	120,000	120,000	120,000	80,000	80,000	80,000
Fuel burnt per year, tons	36,160	75,000	50,625	14,180	19,853	23,472
Cost of fuel per year	144,640*l.*	243,750*l.*	164,531*l.*	56,720*l.*	64,522*l.*	72,287*l.*
Lubricating oil per year, tons	337·35	7·03	6·78	132·3	2·66	3·14
Lubricating oil—cost per year	11,554*l.*	241*l.*	232*l.*	4,531*l.*	71*l.*	108*l.*
Feed-water for boilers per year, tons	2,025	28,000	13,500	794	5,294	6,259
Cost of feed-water for boilers per year	160*l.*	2,217*l.*	1,068*l.*	63*l.*	419*l.*	495*l.*
Engine-room wages per year	10,000*l.*	12,000*l.*	11,000*l.*	6,600*l.*	8,000*l.*	9,000*l.*
Total running expenses	166,354*l.*	258,208*l.*	176,831*l.*	67,914*l.*	73,012*l.*	81,890*l.*
Charges	85,100	70,390	61,605	44,400	32,380	38,850
Total	251,454*l.*	328,598*l.*	238,436*l.*	112,314*l.*	105,392*l.*	120,740*l.*

TABLE IV.

Item.	(*a*) Diesel.	(*b*) Present Turbine Arrangement.	(*c*) With H.P. Turbine Scheme.
Power	5,200 S.H.P.	5,200 S.H.P.	5,200 S.H.P.
Oil consumption, all purposes	1·15 tons per hour	2·09 tons per hour	1·67 tons per hour
Oil per S.H.P. per hour, all purposes	0·5 lb.	0·9 lb.	0·72 lb.
Weight of machinery	740 tons	570 tons	510 tons
R.P.M.	260	260	260
Cost	100,000*l.*	62,000*l.*	65,000*l.*
Cost to run per annum	28,600*l.*	24,500*l.*	22,000*l.*

The possibilities of steam in comparison with the Diesel can be seen from the foregoing tables. The question of the practicability of producing reliable machinery of the (*c*) type is one for the marine engineer. Two difficulties will suggest themselves to him—firstly, that of condenser tubes, and secondly that of steam

* Paper read at the Spring Meetings of the Institution of Naval Architects in London, April 2, 1925.

joints. Some of the land engines of this type which have been successfully run have fresh water for circulation in the condenser, and a leak in the tube is of relatively small importance. The use of possibly leaky condenser tubes with water-tube boilers is not new in ships, and while bad results have been obtained, there is no sign of abandonment of either the condenser or the water-tube boiler either in the navy or the mercantile marine. The second obstacle, that of steam joints, presents no serious difficulties in the land installations, because these installations are usually in large open buildings in which steam leakage of high-pressure high-temperature steam produces no serious results, such as might be the case in a ship. If, however, we look back on the development of the present steam pressures we cannot but be encouraged by the belief that the same skill in the marine engineer which has produced the present steam joints is quite capable of overcoming any further difficulties which may occur.

Sir Charles Parson's proposals are made by a serious engineer who is ready to carry them out. Other firms have been consulted who in this respect are free from the suspicion of desiring favour for their own progeny, and they are quite ready to guarantee results equal to those promised by Sir Charles Parsons, so that there is solid foundation for belief in the statement of steam efficiency upon which the comparison with the Diesel engines is based. Further, one firm has offered equally favourable results in thermal efficiency, first cost, and weight of installation at a pressure of 265 lb. with an installation in which the greater efficiency in the method of producing the steam is expected to make up for the loss of efficiency due to the use of the steam of lower pressure. In this installation coal can be used.

The drawings show Babcock boilers, but though the proposals have come from this firm there are others who are well advanced in their proposals. Messrs. Yarrow and Co. have built boilers of 400 lb. pressure and 700 deg. of superheat, for use in electrical power stations, and they have designed a Yarrow boiler of 500 lb. pressure and about 700 deg. of superheat for marine engines (Fig. 6). Messrs. James Howden and Co. have proposed and are building a boiler of the cylindrical and water-tube type combined which will have 315 lb. pressure and 700 deg. temperature, and with which they expect to get very high efficiency. In Fig. 7, the damper "A" controls the flow of gases through the superheater. That part of the gases which does not pass through the superheater reaches the uptake by the passages marked "B." The feed-water is introduced in the top back drum at "C," whence it passes down the back rows of tubes to the lower drum, where it joins the water coming through the lower pipe from the cylindrical portion of the boiler and passes upwards through the front rows of tubes to the top drum again, from which it enters the cylindrical portion of the boiler at boiler temperature. Both these boilers can be arranged to use oil or coal as fuel. There are others working along the same lines, so that the proposals for the use of high pressure and

Fig. 7.
COMBINED CYLINDRICAL AND WATER TUBE BOILER.

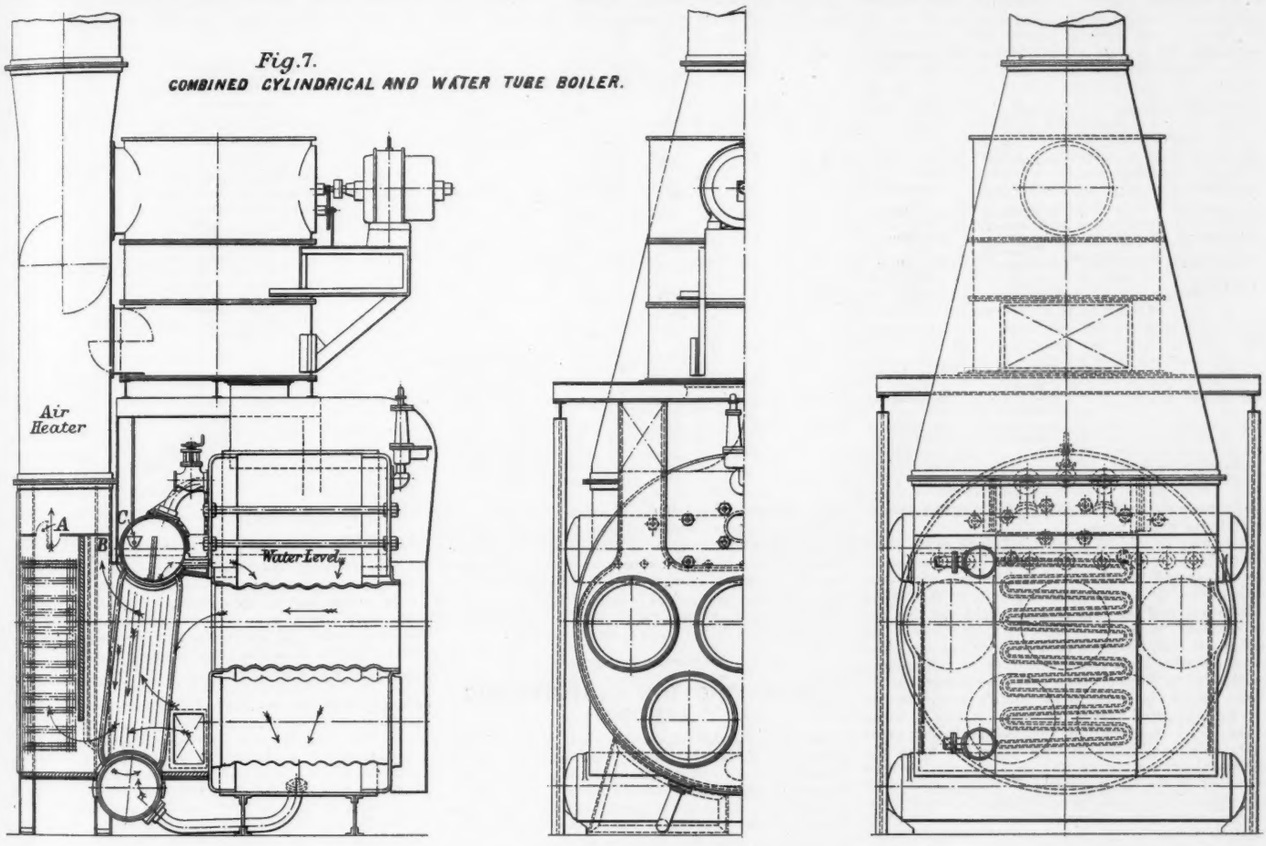


Fig. A. HOWDEN 315-LB. PRESSURE OIL BURNING BOILER.

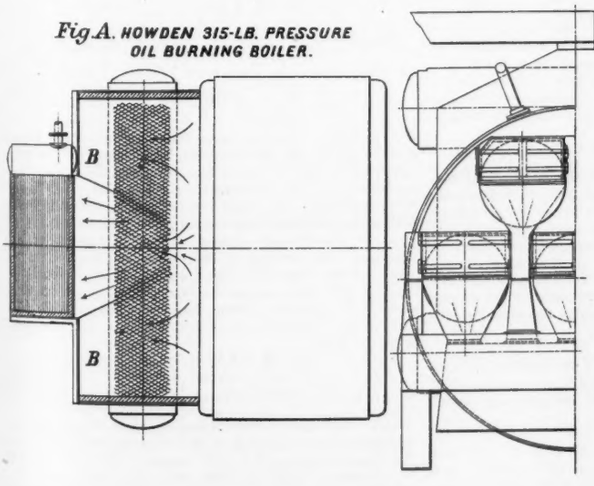


Fig. B. HOWDEN 315-LB. PRESSURE COAL-FIRED BOILER WITH MECHANICAL STOKER.

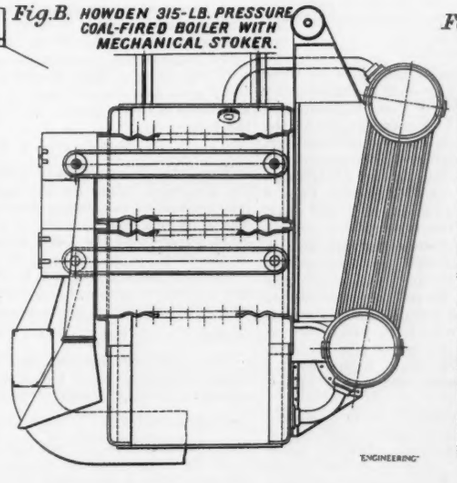
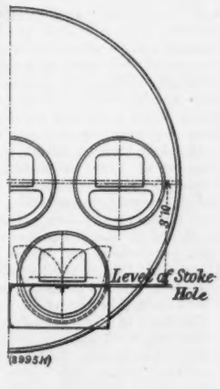


Fig. C. HOWDEN 315-LB. PRESSURE COAL HAND-FIRED BOILER.



ENGINES FOR HIGH-SPEED PASSENGER SHIPS.

APPENDIX II.—PARTICULARS OF DIESEL ENGINES.

Diesel Machinery.			Cylinders in Each Engine.			Revs. per Min.	B.H.P.	Weight/B.H.P. Complete Installation.	Consumption B.H.P.	Cost per B.H.P.
Vessel.	Builder.	Type of Engine.	No.	Diameter.	Stroke.					
				In.	In.			Lb.		
T.S. Dollus	Scott	Scott-Still two-cycle	8	22	36	120	2,500	611	0·36 lb./B.H.P./hr. main engines 0·371 lb./B.H.P./hr. all purposes	Not given.
T.S. Scottish Borderer	Denny	Sulzer two-cycle	4	23·6	41·8	90	2,071	400 main engines only	0·435 lb. includes air, scavenge and other pumps driven off main engines	Not given.
S.S. Pinzon	Beardmore	Beardmore-Tosi	6	24⅜	38⅜	125	1,267	—	0·42 lb./B.H.P./hr. main engines only	31*l.* (1921).
S.S. Pizarro	Beardmore	Beardmore-Tosi	6	24⅜	38⅜	125	1,267	—	0·42 lb./B.H.P./hr. main engines only	—
T.S. Sycamore	Richardson, Westgarth	Beardmore Tosi	6	25⅜	38⅜	126	2,700	—	0·42 lb./B.H.P./hr. main engines only	—
T.S. Tramore	Richardson, Westgarth	Beardmore-Tosi	6	25⅜	38⅜	126	2,700	—	0·42 lb./B.H.P./hr. main engines only	—
T.S. Silurian	Beardmore	Beardmore-Tosi	6	25⅜	38⅜	126	2,700	—	0·42 lb./B.H.P./hr. main engines only	21*l.* 10*s.* (1924).
Q.S. Aorangi	Fairfield	Fairfield-Sulzer	6	27½	39	123	12,200	400	0·431 lb./B.H.P./hr. main engines 0·45 lb./B.H.P./hr. all purposes	—
S.S. Frem	Burmeister & Wain	Burmeister & Wain	6	19·68	35·43	135	Taken at ¾ I.H.P. I.H.P. 1,150 B.H.P. 862·5	452	0·379	31*l.* 6*s.*
T.S. Chastine Maersk	Burmeister & Wain	Burmeister & Wain	6	19·68	35·43	150	I.H.P. 2,300 B.H.P. 1,725	399	0·376	23*l.* 18*s.*
T.S. Tourcaing	Burmeister & Wain	Burmeister & Wain	8	24·8	43·7	130	I.H.P. 5,400 B.H.P. 4,050	393	0·377	18*l.*
S.S. Centaur (as given by Burmeister & Wain)	Scott	Burmeister & Wain four-cycle	6	24·8	54·18	110	I.H.P. 2,000 B.H.P. 1,500	547	0·404	30*l.*

temperature steam are receiving great consideration by several responsible firms.

More may be said on this subject, such as the possibility of the use of coal instead of oil in an emergency, the widespread knowledge of the turbine and boiler installations, the lower centre of gravity of the turbine installation, and the gain in deadweight carrying and its possible increased commercial efficiency; but perhaps enough has been said to draw out the views of others who have given attention to the subject, and to lead to the conclusion that the rumour that the steam engine is dead lacks confirmation. In the oversea high speed vessels the weight is only in favour of the Diesel for a length of voyage considerably above 6,000 miles, and even in such cases the mean displacement on the voyage may be 3 per cent. or more in favour of the steam vessel. For voyages of 3,000 miles there is a gain of over 1,000 tons in weight to be carried, and a gain of 5 per cent. in the mean displacement on voyage in the steam vessel. In cross-Channel vessels the weight and cost make the Diesel prohibitive compared with the turbine. In all these cases the steam is superior to the Diesel in commercial efficiency.

APPENDIX I.

The employment in marine installations of three turbines in series connected by gearing to the propeller shaft is specially appropriate to these high-pressure schemes, since it enables the high-pressure part of the expansion to be effected in a turbine of small diameter, running at the speed of revolution most conducive to efficiency. Thus it is proposed to employ an arrangement similar to that shown in illustrations, Figs. 3 and 5, which represent an installation of 27,000 shaft horse-power on two shafts. The turbines are coupled to the shaft through double-reduction gearing, the high pressure at 4,000 revolutions and the intermediate pressure at 2,700 revolutions driving one primary gear and developing, respectively, 20 per cent. and 30 per cent. of the total power. The remaining 50 per cent. is developed in the low-pressure turbine, which runs at 1,300 revolutions and drives the other primary gear. The main wheel is then symmetrically driven by two secondary pinions of equal power and speed, coupled one to each primary wheel.

The heat of the auxiliary exhaust steam is utilized to heat the feed-water to a temperature of 200 deg. F. Further feed heating can be effected by bleeding steam from the turbine, say, at a pressure of 120 lb. per square inch, to raise the feed temperature to about 310 deg. F. The whole of the heat of the flue gases is available for preheating the furnace air, thus raising the efficiency of the boiler. To remove the objection that has sometimes been raised to the use of water-tube boilers for marine work, having regard to the possibility of leaky condenser tubes admitting salt to the feed system, it is proposed to sub-divide the condensers, fitting two or more condensers to each turbine exhaust, of a large total capacity, with means to isolate each condenser both on the steam and water side, so that on any indication of leakage of salt it may be effectively dealt with without appreciably reducing the speed of the ship. Suitable instruments, of which there are several now on the market, would be fitted for the detection of salinity of the condensate of each condenser. With a boiler pressure of 500 lb. superheat to a total temperature of 700 deg. F., and a condenser vacuum of 29 in. Hg. (barometer, 30 in.), it is estimated that the steam consumption of the turbines of such an installation will not exceed 6·9 lb. per shaft horse-power-hour.

SKIN FRICTION COMMITTEE'S REPORT.*

ALL the available experiment data on the frictional resistance of surfaces have been surveyed by the committee. A bibliographical account of the most important papers on the subject is given in an Appendix. Experiments have been carried out by W. Froude, Gebers, the National Tank, and McEntee and Taylor at Washington, with flat surfaces in water; by Zahm, Stanton, and Marshall and others with flat surfaces in air; by Beaufoy with raft-like bodies; and by Kempf with rounded surfaces in water. The maximum and minimum dimensions of the towed bodies and the speed range of the experiments are given in Table I.

Of this mass of data, Froude's have stood alone for forty years and are still used by the majority of naval architects in this country. Froude reduced his data to the form :—

$$\text{Resistance} = f\ A\ V^n \dagger \quad . \quad . \quad (1)$$

and gave the values of f and n for the whole plank and the estimated values for the last foot of each plank. His method of calculating resistance of long surfaces was to assume that each foot of length beyond the first 50 ft. experienced the same resistance as the last foot of the 50-ft. plank. The work of the other experimenters on flat surfaces is in fair agreement within the limits of the experiments with Froude's data when all such data are plotted in the generally accepted modern method, *i.e.*, in the form of $\frac{R}{\rho\ A\ V^2}$ to a base of $\frac{V\ L}{\nu}$.

This mode of analysis serves to explain certain apparent idiosyncrasies, but it still leaves a method of extension to long lengths or high speeds to be found. The highest value of $\frac{V\ L}{\nu}$ for which resistance has so far been obtained with any flat surface, is $54{\cdot}5 \times 10^6$ (see Table I). The value of this term for a 400-ft. ship steaming at 10 knots at sea, is 517×10^6, or 9·5 times farther up the scale than the greatest known value. An attempt to extend the known range of data was recently made by Kempf, who measured the resistance of a cylindrical tube up to $\frac{V\ L}{\nu}$ value of 213×10^6. His published results show resistances considerably above those of any other experimenter (see Table II). It is to be noted that his proportions of girth of wetted surface to length were excessively low, especially for his long forms. If his results are accepted as useful when applied to a ship, the estimate for the above 400-ft. ship has still to be made at a $\frac{V\ L}{\nu}$ value two and a half times higher than Kempf's highest value. Various proposals have been made from time to time to overcome this difficulty. W. Froude's has already been mentioned. R. E. Froude at a later period adjusted these data in the light of further model work and produced his "O_m" and "O_s" method, in which resistance was taken to vary as $V^{1.825}$ for ship and model.

The Froude Tank in 1915 proposed that the frictional resistance may be extended by the formula :—

$$R = k_1\ A\ V^2 \left(\frac{V\ L}{\nu}\right)^{-0.138} \quad . \quad . \quad (2)$$

Gebers's more recent attempt (1921), based on a $\frac{V\ L}{\nu}$ plotting, consists in a one-term formula of the form :—

$$R = k_2\ A\ V^2 \left(\frac{V\ L}{\nu}\right)^{-0.125} \quad . \quad . \quad (3)$$

i.e., resistance varying at a little higher power than Froude gave. Blasius, Gumbel, Shigemitsu, and others have proposed to regard the frictional resistance as made up of two portions :—(i) That due to a thin boundary layer, of which one side is in contact with and moves with the same velocity as the moving surface and the other is in contact with a turbulent wake, assuming viscous flow in this belt. (ii) That due to waste in this outer turbulent wake. In the boundary layer, with the assumptions made, the resistance will vary as $V^{1.5}$, in the surrounding turbulent layer it will vary as V^2. The formula obtained in any such analysis is of the form :—

$$R = A\ V^2\ (f_1 + f_2)$$

here f_1 and f_2 are functions of $\frac{V\ L}{\nu}$. Such an analysis enables the relative importance of these two forms of resistance to be assessed, if and when the characters of the functions f_1 and f_2 are known. Forms of these functions, at least for the boundary layer, can be developed if certain assumptions are made, but such assumptions are known to be doubtful. The extension of such empirical formulæ beyond the limits of experiment data will therefore be open to the same type of error as Froude's original method of extension.

As an example of the variety of results which can be obtained with the existing data, two estimates have been made of frictional resistance :—(i) Of a vessel 400 ft. long, wetted area—30,000 sq. ft. at 25 knots; (ii) of a vessel 172·5 ft. long, wetted surface—7,540 sq. ft. at 10 knots. These estimates are given in Table II, and have been made in five different ways, viz. :—(i) From W. Froude's original data; (ii) from

* Presented to the Institution of Naval Architects, London, on Thursday, April 2, 1924. Abridged.

† Nomenclature throughout report: A = area of wetted surface; R = frictional resistance of surface; V = velocity of surface; L = length of surface in direction of motion; $\nu = \frac{\mu}{\rho}$ = kinematic velocity of the fluid; μ = viscosity of fluid; ρ its density; f in equation (1), k_1 in equation (2), k_2 in equation (3), are constants varying with the condition of surface, &c.

R.E. Froude's O_m and O data; (iii) from the National Tank analysis data; (iv) from Gebers's data; (v) from Kempf's data, using the formula derived by him from his experiments. It is desirable to point out that both W. Froude and R. E. Froude intended the results obtained by their methods to be taken as applying directly to a ship, *i.e.*, they must be taken as covering any form effect, &c. The National Tank estimate includes no allowance for form. Herr Kempf has applied his results to the calculation of ship resistance without any addition or correction for "form" or plate butt effect. The National Tank estimate is for a clean-painted smooth surface and is corrected for plate edge, &c., effects in the figures given in the Table. Gebers's estimate is for a smooth surface.

Of these methods of extension only Froude's take any account of the increase in resistance due to the flow being around a solid body instead of a flat surface. Experiment data suggest that this varies from a negligible quantity to 10 per cent. or 12 per cent., according to the character and relative dimensions of the hull form. This portion of the resistance of a model has so far been treated as residuary resistance, i.e., it is assumed to vary as V^2 instead of, say, $V^{1.825}$ with Froude's data. The error in the ship estimate due to this assumption has been calculated and is given in the diagram above. It varies from, roughly, 1 per cent. for fine high-speed forms to 6 per cent. or 7 per cent. for the cargo-boat type, the estimate always exceeding the true value.

Difficulties arise when an attempt is made to compare resistance estimates with the results attained on speed trials. In some cases there is every appearance of agreement, and exceptionally good results are not unknown, but a number of bad results have been reported. The measurement of thrust on ships should remove some of the difficulties in making such comparisons; but in the few merchant ships in which thrusts have been measured these have always exceeded the estimated thrust, the excess varying upwards to 20 per cent. There are two possible explanations for these excesses, viz., excess of resistance or an increase in the "augment" due to the interaction between hull and propeller—there is no certainty at present as to which of these is the source of the error. In the Greyhound experiments the frictional resistance exceeded the estimate made from model data by 27 per cent. At the time this was attributed to a rough bottom. The ship was copper-plated and free from the thick plate butts and edges and rivet-points of modern ships. On the other hand, the copper was said to be deteriorated.

The Committee have considered the possible modes of extending the known data. There appeared to be two desirable courses: (i) to experiment with long flat surfaces; (ii) to tow a ship and measure its resistance. Method (i) frankly ignores the difficulties which arise when form effect and roughness due to laps, &c., are considered; but if carried out it would give positive data on the rate of variation with velocity for a smooth surface and eliminate this great source of trouble in forming estimates. Such a plank or flat surface should have a proportion of girth to length approximately the same as for a normal ship, and should be towed at a steady velocity without any yawing off its course. These requirements were considered in considerable detail, and some experiments were carried out in the national Tank on the directional stability of a towed plank. The Committee are agreed that the difficulties in making such tests in the open are very serious, and that progress in this direction must at present be limited to what can be done in an experiment tank. Some advance could be made in a tank; but the limitations are very marked, the greatest length that could be tried is about 76 ft., and the greatest speed 20 ft. per second, corresponding to a $\frac{V L}{\nu}$ value of 146×10^6.

After some consideration it was decided that the form most suited for a towing test with a ship was a destroyer. The effect of its "form" or "body" on resistance can be obtained closely; it can be towed at moderate speeds without appreciable wave motion,

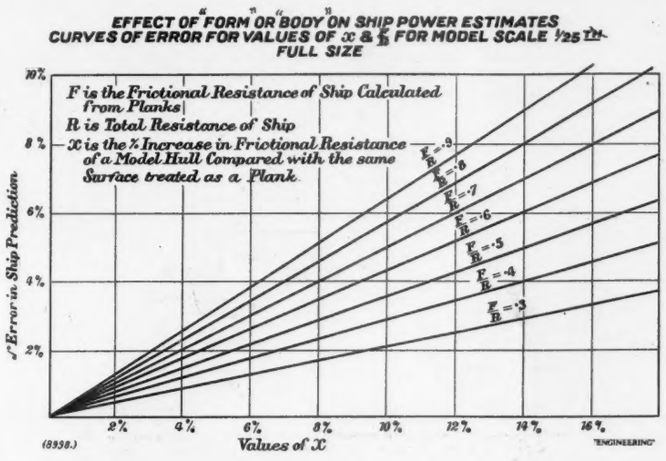


TABLE I.—EXISTING DATA—DIMENSIONS AND SPEEDS OF TESTED SURFACES.

Experiments by, and Place.	Plank Dimensions and Speed. Maximum. Length in Feet.	Depth in Inches.	Maximum Beam in Inches.	Speed Range, Feet per Minute.	Minimum. Length in Feet.	Depth in Inches.	Maximum Beam, in Inches.	Speed Range, Feet per Minute.	Remarks.
W. Froude, Chelston Cross	50	19	0·19	650–100	1	19	0·19	940–400	Planks fitted with cut-water at each end run with upper edge 1·5 in below surface.
	Highest $\frac{V L}{\nu}$ value, 41×10^6								
Herr Gebers, Vienna	32·8	19·7	0·79	1,500–140	3·28	14·8	0·12	1,600–100	Planks fitted with cut-water and run with upper edge projecting through surface. Small plank is of brass.
	Highest $\frac{V L}{\nu}$ value, $54·5 \times 10^6$								
Herr Gebers, Dresden	21·4	15	0·32	925–100	1·97	15	0·08	1,000–200	Planks fitted with cut-waters and run with upper edge projecting through surface.
	Highest $\frac{V L}{\nu}$ value, $16·6 \times 10^6$								
Beaufoy (1793), Greenland Dock ..	42·2	14·6	14·6	810–60	—	—	—	—	These were planks in the ordinary sense of the word and were run with and without shaped ends.
William Froude, National Tank, Teddington	16	11	4	546–189	3	11	0·62	1,153–100	Numerous small forms were run, some on the surface and some submerged. Planks were triangular in transverse cross-section with slightly rounded keel. Plank was shaped to knife-edge at ends.
	Highest $\frac{V L}{\nu}$ value, $10·47 \times 10^6$								
McEntee and D. W. Taylor, Washington	20	24	0·7	1,100–	10	14·4	0·6	—	Planks run below surface. Long planks 8 in. below. Short planks 15 in. below
Kempf, Hamburg	202·5	Tube 13·78 diameter, about two-thirds immersed		1,300–150	24·6	Tube 13·78 diameter, about two-thirds immersed		1,380–150	Form consisted of metal tubes screwed together and painted cap pieces fitted at the ends.
	Highest $\frac{V L}{\nu}$ value, $213·4 \times 10^3$								
Zahm's Experiments	16 17·17 with ends	25·5	1	2,400–300	(2) 3·17 with ends	25·5	1	2,400–300	Experiments conducted in wind channel 6 ft. square and 40 ft. long.

The $\frac{V L}{\nu}$ value necessary for a 400-ft. ship at 10 knots $= 517 \times 10^6$ for 55 deg. F.

TABLE II.—*Estimates of Frictional Resistance.*

For surfaces 172·5 ft. and 400 ft. in length. Estimates made according to methods and experiment data obtained by five different authorities.

—	Resistance in pounds for:— 7,540 sq. ft. of Surface, 172·5 ft. in Length, 10 Knots Speed.	30,000 sq. ft. of Surface, 400 ft. in Length, 25 Knots Speed.
W. Froude's method for ship ..	4,590	94,600
R. E. Froude's data for plated ship	4,560	94,400
National Tank { Smooth ..	4,390	85,100
National Tank { Plated ..	4,830	93,600
Gebers (smooth)	4,200	80,000
Kempf (painted iron)	5,240	128,200

and the thinness of its plating reduces the edge and butt effects to a minimum. It was also thought that a hull of this form was more likely to be available than any other. The question of the practicability of towing such a form by means of another destroyer was referred to the Admiralty. Their Lordships have replied that they do not consider there would be any great difficulty in carrying out such operations. Tests of models of the hull (i) on the usual scale, (ii) on the largest feasible scale, would be made in a tank to obtain the fullest data possible for speeds up to about 16 knots—the approximate speed at which wave-making will be noticeable and towing difficulties may arise. It would also be desirable to have a model of the hull tested in a wind channel at the highest possible speed to check against the tank data.

There are a number of difficulties which have to be overcome, apart from the question of steady towing already referred to. The principal of these are

concerned with (i) manner of towing; (ii) steadiness of velocity; (iii) directional stability; (iv), weather conditions; (v) deterioration of the painted surface. The opinion was held by some members of the committee that these factors were so uncertain that it was not likely that trustworthy and consistent results would be obtained. If the general principle of such experiments be approved, it is proposed to carry out preliminary experiments in a tank to determine in what positions one destroyer model may be towed relative to another well ahead of it, without its resistance being affected. The taking of continuous records of speed and resistance would reduce the error arising from any small unsteadiness of speed. To maintain directional stability a rudder will have to be retained on the hull, and its resistance be separately estimated and deducted from the whole. Deterioration of surface is more difficult to deal with. It has been stated that this deterioration is equivalent to ½ per cent. increase in frictional resistance per day out of dry dock. A well-authenticated case of a ship lying at Newcastle for three months showed 24 per cent. increase in frictional resistance, or, roughly, one-half that given by the above figure. Data on this subject have been obtained in the Dumbarton Tank with rotating discs, and it is proposed to make a few model experiments on the subject. The towing experiments may be expected to occupy three or four weeks, as they could only be carried out when the weather was favourable. Under suitable circumstances a measure of this time effect could be obtained; but, in any case, it is considered that the effect of a delay of a week or so will not be great, and can be estimated sufficiently well for the purposes of the tests.

In addition to the measurement of the towing force on the hull, it is proposed to obtain as many data as possible relative to the thickness of wake and distribution of velocity in the frictional wake. Such data, if taken at a number of sections along the ship, would enable the variation of total momentum in the water to be obtained and be of great assistance in determining the distribution of resistance along the hull. The suggestion has been made that by the use of a thrust meter valuable information as to the skin friction on the hull might be obtained, but the Committee has not discussed the matter in detail. While some of the difficulties inherent in the tow-rope method would be removed, other difficulties, *e.g.*, those dependent on the interaction between the hull and propeller, would be introduced, and, without greater experience than has yet been acquired, it is impossible to estimate the accuracy obtainable. At the same time, should a direct tow-rope experiment prove out of the question, it would be well to examine most carefully the possible use of a thrust meter.

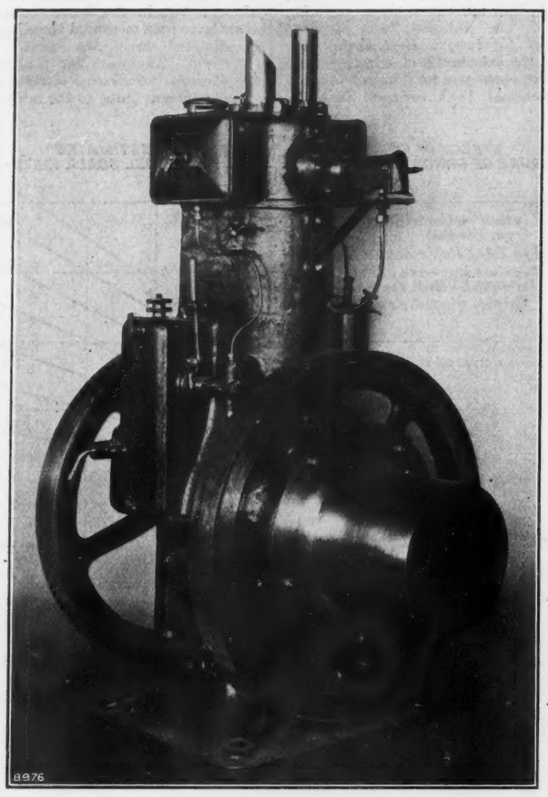
The Committee have not considered it to be any part of their duty to investigate the details of any proposals here made, beyond assuring themselves of their practicability and usefulness. The Committee are unanimous in their conclusion that much more could be done to extend our knowledge of skin friction by experiments in a tank, although very considerable extension of the data would still be required in framing ship estimates. With regard to the towing of a destroyer hull, a majority of the Committee are of opinion that this should give the additional data required, and that, although such tests represent a fairly serious outlay, the importance of the data to be obtained would appear to justify incurring the expense involved if the necessary funds could be raised.

STANDARD SPECIFICATION FOR SPRING STEELS FOR AUTOMOBILES.—Publication No. 5010—1925, of the British Engineering Standards Association, entitled "Schedule of Steels for Laminated Springs for Automobiles" gives the chemical composition of six classes of these steels for automobile springs, sizes of sections and the permissible margins which manufacturers are allowed on the widths and thicknesses. Copies of the specification may be obtained from the Association, 28, Victoria-street, London, S.W.1, price 1*s.* 2*d.* post free.

PIG-IRON PRODUCTION IN FRANCE.—The pig-iron production in France during the year 1924 reached a total of 7,693,018 tons, thus exceeding the production of 1923 by 2,261,231 tons, or 41·6 per cent. The production for 1924 is 84·8 per cent. that for 1913, which amounted to 9,071,000 tons. The Comité des Forges de France, in one of their bulletins on the subject, add that the number of furnaces in blast was 127 at the commencement, and 133 at the end of the year. At the latter date there were 39 blast furnaces idle, and 48 in course of construction or repair, making a total of 220. The men employed at the blast furnaces numbered just over 22,000. According to quality, the production comprised 87·1 per cent. of phophorous pig-iron, 10·4 per cent. of hematite and 2·5 per cent. of ferro-alloys. In the same year France utilised 19,323,927 tons of iron-ore mined in her own territory, 420,850 tons imported from Luxemburg and 273,150 tons from Tunis, Algiers, Morocco, Russia, Spain, Sardinia and Sweden. The manganese ore was imported from Brazil, Russia, India and other countries.

10-H.P. SEMI-DIESEL OIL ENGINE.

CONSTRUCTED BY THE USINES RENAULT, BILLANCOURT, PARIS.



10-H.P. SINGLE-CYLINDER SEMI-DIESEL, RENAULT ENGINE.

WE illustrate in the accompanying figure a 10-h.p. internal-combustion engine, built by the Usines Renault of Billancourt, near Paris, whose establishments we described in our issue of May 26, 1922. This is a four-cycle engine, of the enclosed type, having a cylinder 140 mm. (5½ in.) in diameter with a 220-mm. (8⅝ in.) stroke, and running at a speed of 800 r.p.m. The bed forms the lower portion of the engine casing, and has long bearings for the crankshaft. The cylinder is cast in one piece with its water-jacket, and is provided with a detachable head. The connecting rod is of steel, machined throughout; the big end has a brass bush lined with regulus metal the bush at the other end being of phosphor-bronze. The piston rod is of specially heat-treated steel and the piston of cast-iron, strongly ribbed and finished with five grooves at its upper part for rings. The layshaft is vertical, and is operated by helical gearing, and runs in two short brass bushes at each end. Lubrication is by a gear pump worked from the crankshaft and immersed in the lubricating oil at the bottom of the casing. The engine has two heavy flywheels designed for a speed variation not exceeding 1/70; a belt-pulley 300 mm. (11¾ in.) in diameter is fitted to one of them. The engine weighs about 1,600 lb.

In the course of tests carried out by the French Automobile Club and using shale-oil, the average power at full-load was 8·948 h.p., and at half-load 4·904 h.p. The average speed in the first case was 825·8 r.p.m., and in the second 837·7. The length of run at full load was 44·74 hours, and 24·54 at half-load. The shale-oil consumption per h.p-hour, full-load, was 0·3678 kg. (13 oz.), and 0·472 kg. (16·7 oz.) half-load. The lubricating oil consumption during the tests was practically negligible.

LAUNCH OF THE S.S. "CITY OF DELHI."—On March 24 Messrs. William Gray and Co., Limited, launched from their Wear shipyard the steamer "City of Delhi," which is being constructed to the order of the Ellerman Lines, Limited. The overall length of the vessel is 469 ft., the extreme breadth 58 ft. 7 in., and the moulded depth to the upper deck 34 ft. 9 in. The gross tonnage is 7,600 and the deadweight 12,000 tons. Tanks in the double bottom are arranged for the carriage of oil fuel when it is desired to use the latter in the boiler furnaces. Steam piping fitted around the suction passages permits of heavy oil being liquified by heating. The vessel is of the two deck type with long poop and combined bridge and forecastle. Part of No. 1 'tween decks and the whole of No. 2 'tween decks are insulated for the carriage of chilled meat. The Central Engine works of the builders are supplying engines of the balanced quadruple expansion surface condensing type, having cylinder 24, 35, 51, and 74 in. in diameter and 51 in. in stroke, and also four large multitubular boilers operating at a steam pressure of 250 lb. per square inch, working under forced draught and arranged for burning either oil or coal. Wilson-Pirrie steering gear will be fitted in a steel house on the upper deck inside the poop and operated by a telemotor from the navigating bridge. Sixteen winches and eighteen derricks will handle cargo, these and other auxiliaries being steam driven.

A VERTICAL ROTARY CARBONISATION RETORT.—The rotary low-temperature carbonisation retort of the Megiun A.G., at Butzbach, differs from others chiefly in one respect. The retort is externally heated, but the vapours liberated collect in the inner side portion of the retort, being protected against overheating by a double shell of steel and the coal under carbonisation. The other features are, more or less, combinations of known devices. This consists of a vertical drum rotating at a rapid rate within the setting. Inside this drum turns a second drum, at a slower rate; the two drums are supported on the same vertical shaft. The outer surface of the inner drum is fitted with a helical conveyor fin and the coal descends on this helix in the annular space between the two drums. Owing to the rapid rotation of the drum, the coal is thrown against this shell, which is exposed to the furnace flames, especially in the upper portion; the lower portion of the furnace is not heated. The inner shell is perforated, and the vapours liberated pass through the perforations into the inner space of the retort, which is much wider than the annular space. From this inner space the vapours are withdrawn upward. Experiments which have been continued for several years in a small plant show that a superior low-temperature tar is produced, fairly free of dust, and is quite as good a yield as Professor F. Fischer has realised with his aluminium retort in the Institut für Kohleforsihung; oil benzine, &c., can be separated from the tar. The further product is a good semi-coke. The experiments have been made with various coals and lignites, and a point of interest is that coal dust and lignites high in earthy constituents, otherwise not amenable to retort treatment, have been carbonised.